ASSESSMENT OF UNREINFORCED MASONRY BUILDINGS WITHSTANDING LATERAL LOADS BY CAPACITY CURVE

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ABSTRACT :

According to the variety and distribution of the masonry buildings across the world, numerical modelling and analysis of these sorts of buildings is one the most interesting subjects for researchers. In such buildings, masonry shear walls are the main earthquake resistant components. Evaluation and analysis of different models of unreinforced masonry buildings, is the main aim of this research. In this manuscript, by the means of the existing computational programs, some parametric models are presented and compared for the unreinforced masonry buildings. A nonlinear static (pushover) analysis is carried out in these models. The models differ in number of openings, height of openings, arrangement and distribution of openings along the walls. These comparisons result in determination of the behaviour of unreinforced masonry buildings due to the variation of the capacity curve of these structures.

KEYWORDS: Masonry, Capacity Curve, Lateral Load, Evaluation.

1. INTRODUCTION

Different methods of analysis have been performed for unreinforced masonry (URM) buildings in the last few years. Methods such as finite elements, discrete elements and equivalent frame methods have been used recently. The finite element method involves two types of modeling for masonry structures: macro modeling and micro modeling. In this paper the evaluation method performed by K. Lang and H. Bachmann is used for preparing the models. This document provides several models comparing different characteristics of these buildings against lateral loads. The comparisons are done due to the seismic behaviour of the URM buildings under lateral loads by plotting their capacity curve. The models differ in: number of openings, opening heights and opening arrangement.

2. DESCRIPTION OF THE METHOD

The evaluation method performed by K. Lang and H. Bachmann is based on a comparison of the seismic demand on the building with the capacity of the building. The capacity of the building can be expressed by a capacity curve which is defined as the base shear acting on the building versus the horizontal displacement of the top of the building. This curve is also known as a pushover curve. Plotting this curve, at the next stage, we can obtain the vulnerability function by relating the top displacement as a result of a certain level of ground motion, to a measure of damage. In this method it is assumed the floors being completely rigid and torsional effects being neglected.

The capacity curve of a URM building is calculated by superposition of the capacity curve of each individual wall (Eqn. 2.1).

$$V_b(\Delta) = \sum_j V_j(\Delta) \tag{2.1}$$

J is the index of the walls.
Therefore the stiffness of the linear elastic part of the capacity curve will be:

$$k = \frac{V_{bm}}{\Delta_{by}} = \sum_j k_{eff_j} \tag{2.2}$$

Where, V_{bm} is the shear capacity and Δ_{by} is the nominal top yield displacement of the building.(K. Lang and H. Bachmann,*2003*)

3. MODELS

Perforated masonry walls consist of several elements. These elements are shown in figure 1.

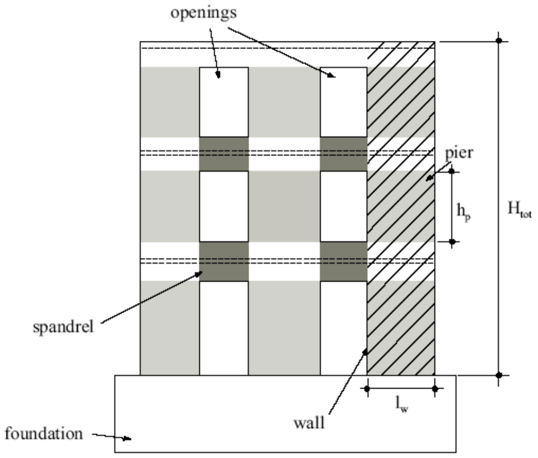


Figure 1 Perforated wall

In this research three characteristics of a URM building are modelled according to the described method. The first characteristic described in section 3.1 is the number of openings. Three URM buildings which differ in number of openings are compared in this part. The second variable is the opening height which will be presented in section 3.2. In this section the effect of height of openings on the capacity curve of the walls will be depicted. Finally the third parameter will be the arrangement and distribution of the openings discussed in section 3.3.

3.1. Effect of number of openings on the capacity curve of URM buildings

The capacity curves of three models with different number of openings and equal opening area, shown in figure 2, are compared. The material and geometrical properties of these models can be found in table 1.

Table 3.1 Material and geometrical properties

Overall Geometry		
Total floor area	66.2	m^2
Total building height	5.84	m
Story height	2.92	m
Material		
Compression strength orthogonal to the mortar bed	5.1	MPa
Compression strength parallel to the mortar bed	1.53	MPa
Angle of internal friction	0.8	
Modulus of elasticity of masonry	3000	MPa
Shear modulus of masonry	1000	MPa
Stiffness reduction factor	0.5	
Specific weight of massive brick masonry	16	kN/m^2

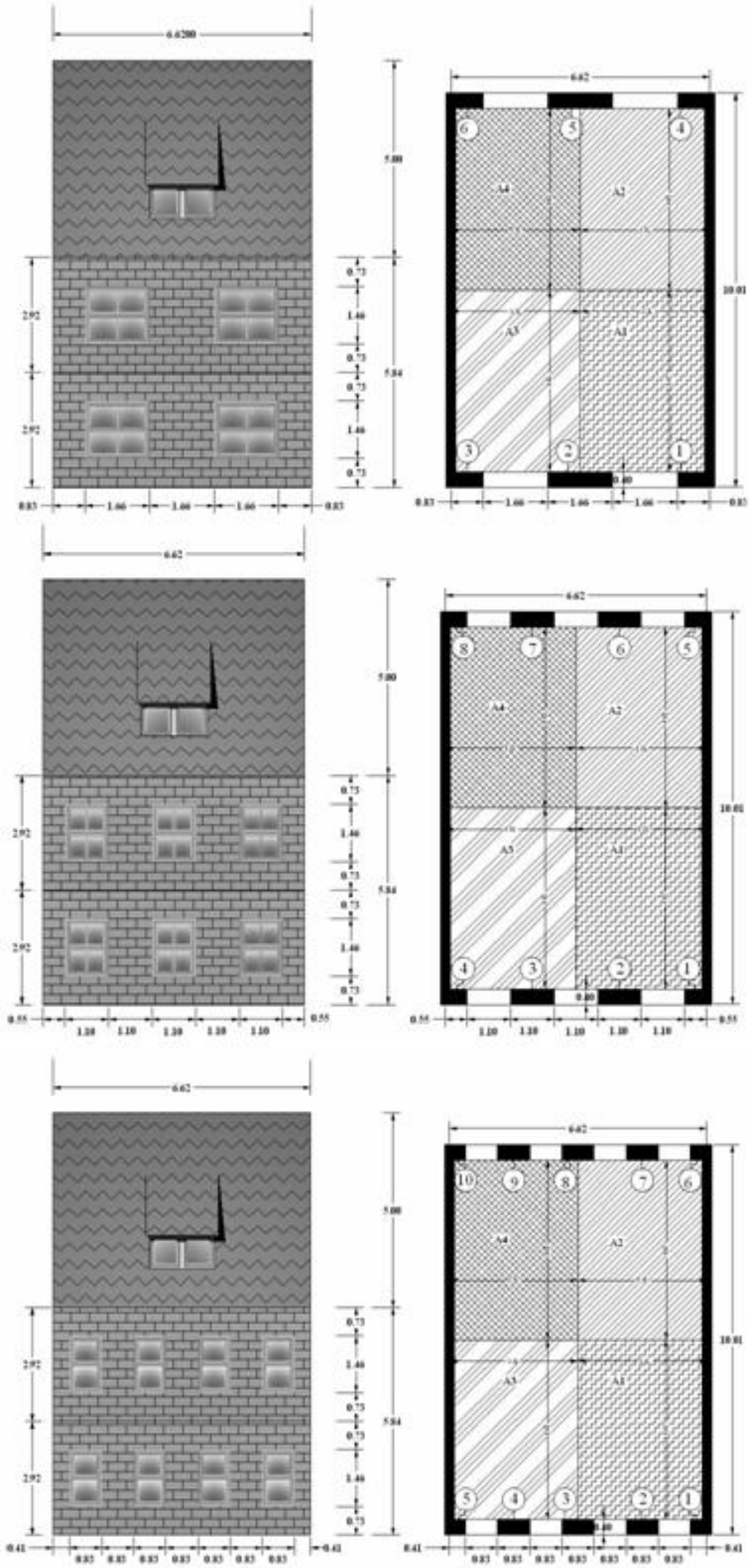


Figure 2 Elevation and plan of URM buildings differing in number of openings

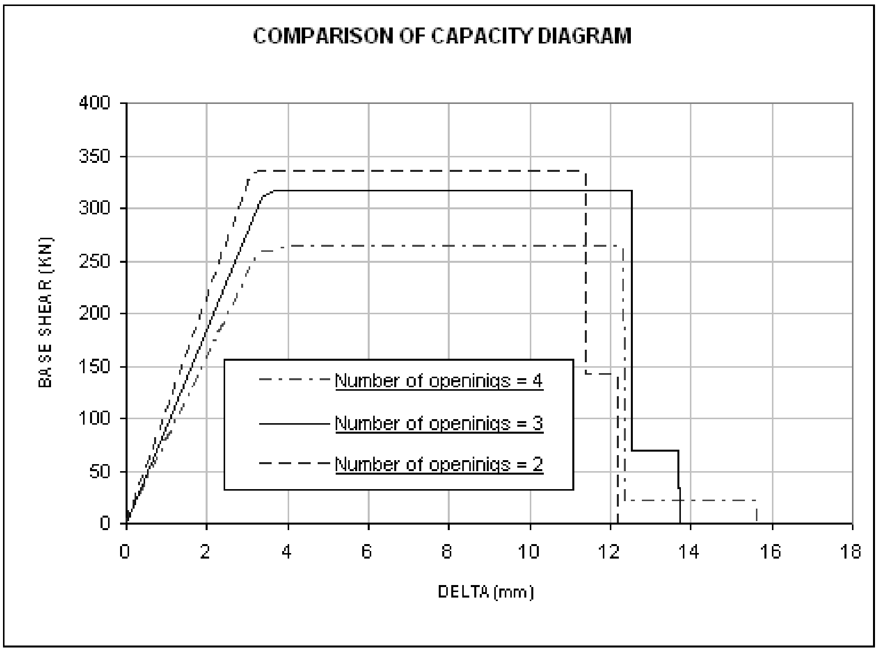
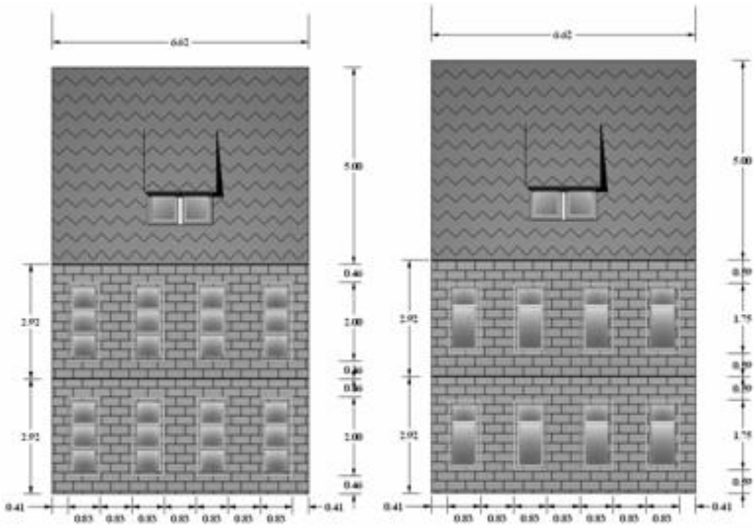


Figure 3 Capacity curves of URM buildings differing in number of openings

3.2. Effect of opening heights on the capacity curve of URM buildings

The capacity curves of five models with opening heights of 100, 125, 150, 175 and 200 centimeters, shown in figure 4, are compared. The material and geometrical properties of these models are the same as table 1.



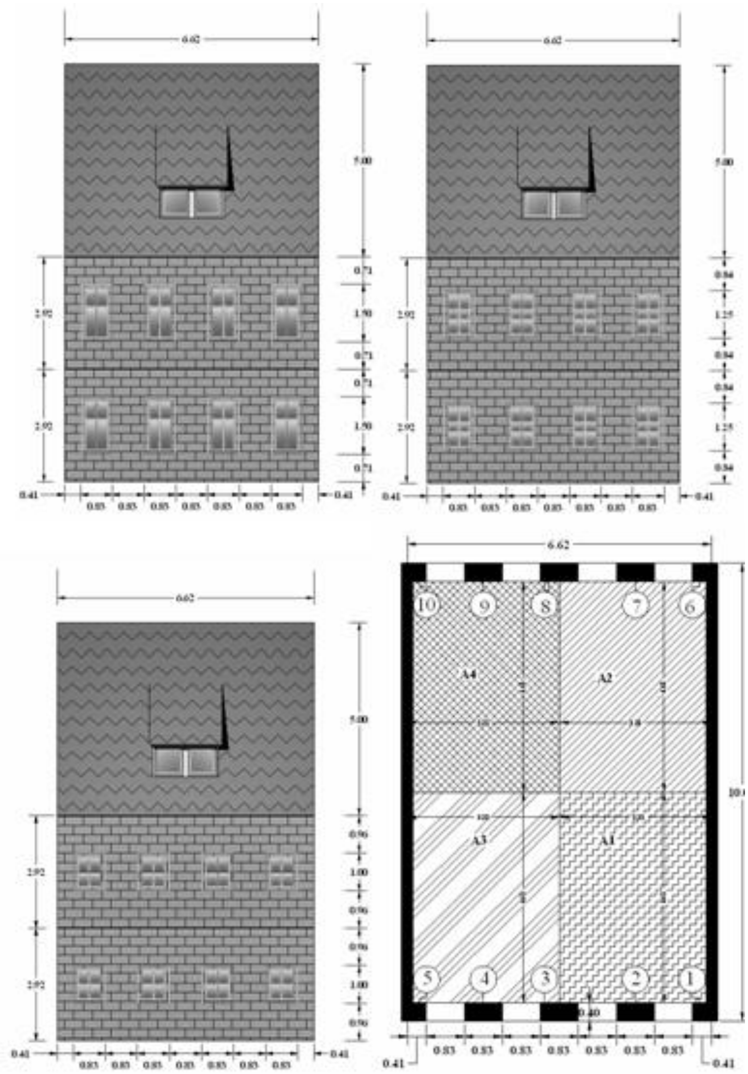


Figure 4 Elevation and plan of URM buildings differing in height of opening

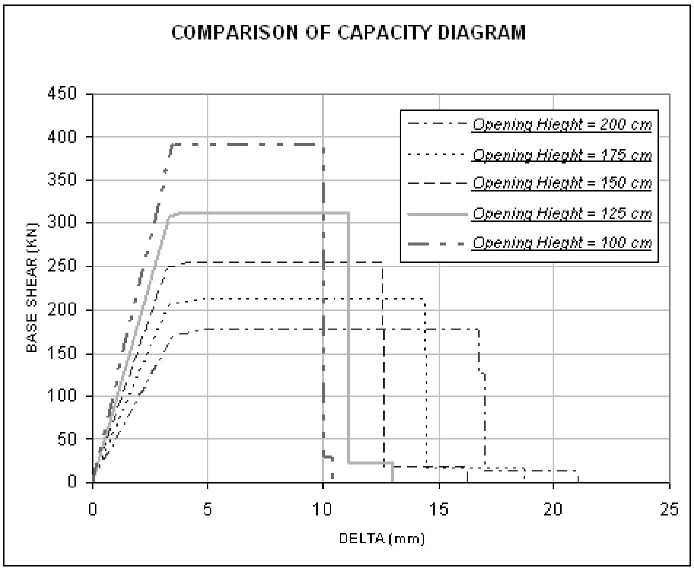


Figure 5 Capacity curves of URM buildings differing in height of opening

3.3 Effect of opening arrangement on the capacity curve of URM buildings

The capacity curves of four models with different opening arrangements, shown in figure 3, are compared. The material and geometrical properties of these models are the same as table 1. As shown in figure 6 the opening height and width is equal in all of the models.

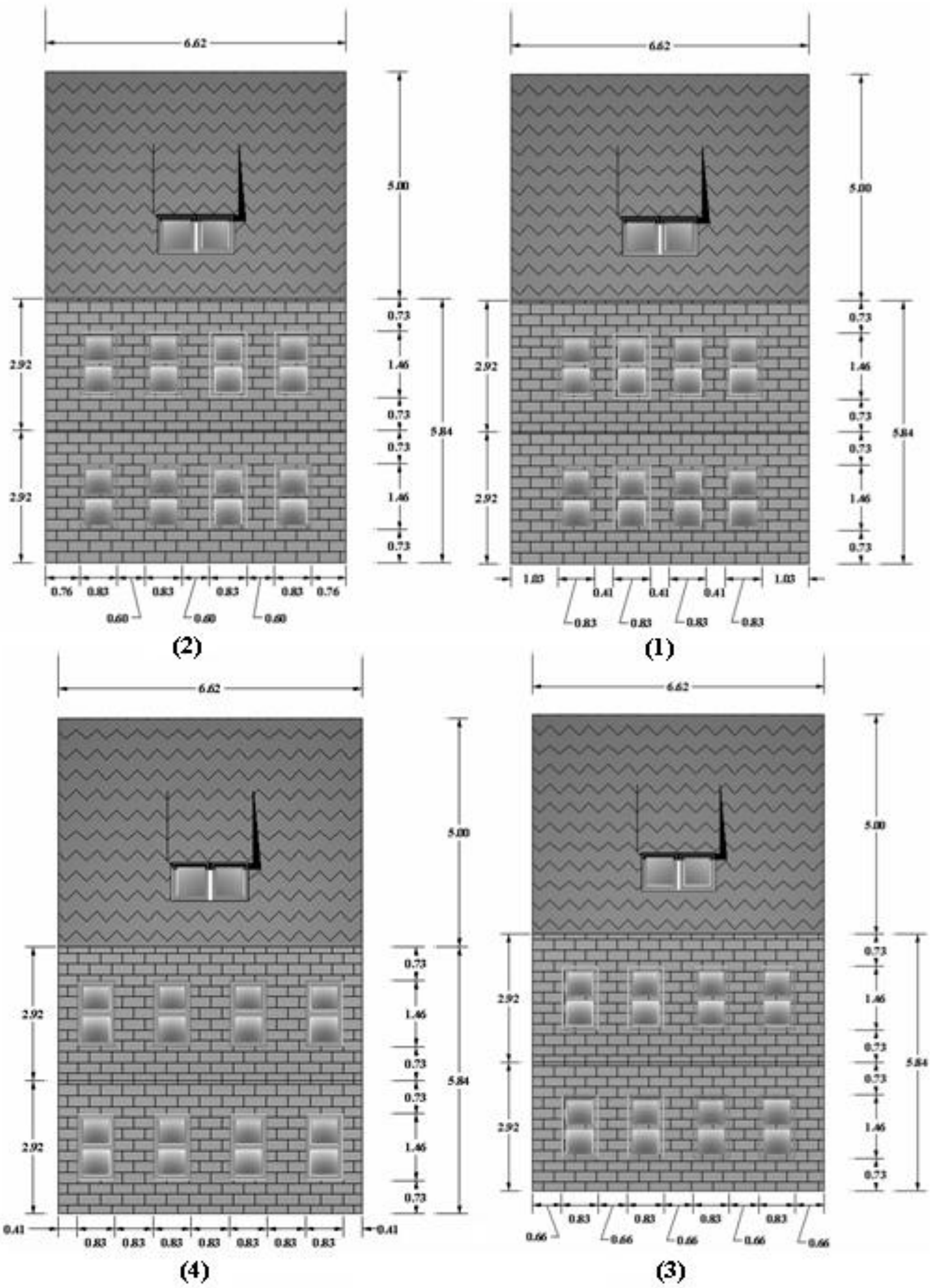


Figure 6 Elevation of URM buildings differing in arrangement of openings

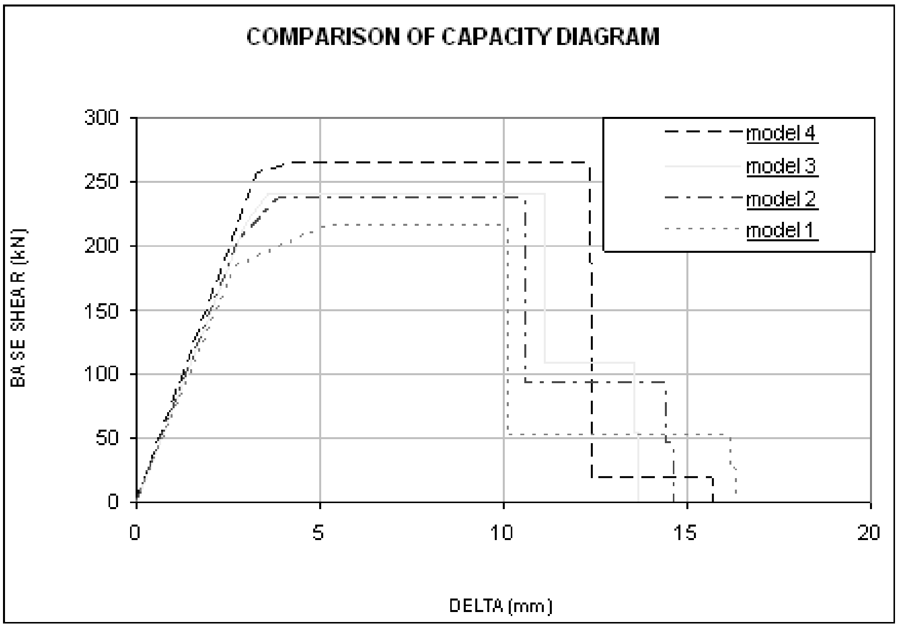


Figure 7 Capacity curves of URM buildings differing in arrangement of openings

4. CONCLUSION

As observed in figure 3, by increasing the number of openings (total area of opening remaining constant) in masonry buildings a decrease in the maximum base shear sustained by the building will occur and the elastic stiffness of the whole structure will reduce. Figure 5 depicts the effect of opening heights in masonry buildings on their capacity curve. It is understood that buildings with small opening heights have a stiffer behavior while increasing this height will improve the ductility of the structure. Arrangement of the openings affects the capacity curve of masonry buildings. The capacity curves of four models are compared in figure 7. The base shear sustained in model 4 -where the openings are placed with the maximum space between them- is about 1.3 times more than model 2 which the openings are close to each other. A slight difference between the elastic stiffness of the models can be seen in figure 7.

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