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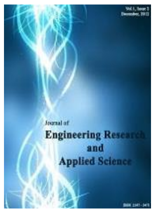

Investigation of numerical analysis according to two different methods of a existing masonry building

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Abstract

Masonry buildings are a particularly preferred type of structure, especially in rural areas. There are many reasons why it is preferable such as the material in the region can be used, the material can be supplied economically, the production is fast, natural heat insulation. Masonry buildings are brittle buildings. Faults especially during construction and during the project phase further reduce the earthquake performance of such buildings. It is very important to know earthquake behavior of masonry buildings and to take precautions by analyzing buildings accordingly. There are many masonry buildings in rural and urban centers in Turkey. Generally these buildings are constructed without project, without engineering service. For this reason, such buildings are highly risky buildings during a possible earthquake. Determination of the earthquake performances of these buildings is a very important issue therefore to take earthquake performances to the required level. In recent years, many researches are conducted about analysis of earthquake performance on historical buildings and in service buildings. Many different methods for earthquake analysis of masonry buildings have been developed. One of these methods is the method of claiming that the masonry walls will take the earthquake load in proportion to their stiffness. This method is accepted as an analysis method in Turkish Seismic Code-2007 (TSC-2007). In this study, an existing masonry building analysis is performed according to the method given in TSC-2007. Method defined in excel file for accountability. The results of the two methods were compared by performing an analysis on the ETABS program.

Keywords: Masonry buildings; TSC – 2007; masonry pier; seismic performance; finite element method.

1. Introduction

Masonry buildings are a type of construction applied all over the world. Masonry buildings are preferred due to its durability and easy manufacturing. There are many buildings still standing for hundreds of years [1]. It is very difficult to determine earthquake behavior of masonry buildings. Because earthquake behavior of masonry buildings depend on many properties such as material properties, geometry, foundation, connection between walls and floors, connection between roof and walls [2].

It is a type of composite construction consisting of masonry units and mortar. Masonry building units may consist of materials such as bricks, ashlars, stone and blocks. The characterization of masonry buildings is a suitable type for structural units depending on the pressure stress due to vertical static loads [2]. Masonry buildings are actually rigid structures with small natural vibration periods. However, this properties does not mean that masonry buildings is earthquake resistance building [3]. Masonry units are units that have a direct impact on the earthquake performance of masonry buildings and can be very damaging during large earthquakes [2, 4-6]. Massive damage during earthquakes in masonry buildings is usually due to insufficient connection, use of poor quality materials, rubble stone using [7].

Turkey is a country that large part of is located on active seismic zone [8]. There are substantial masonry building in the building stock in Turkey [9]. Many of these buildings are building that do not provide earthquake safety [10]. Realistically, determination of earthquake behavior of these structures will prevent loss of life and property in earthquakes that may be experienced [9]. In recent years earthquake performance of masonry buildings has become an important issue. The number of studies on this subject has increased [11].

In this study, earthquake performance of an existing masonry building is evaluated. The earthquake

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performance of the building is solved by the method prepared as an excel table according to the method of transferring the shear force to the wall depend on stiffness ratio defined in TSC-2007. In the study, this method is called 'Excel Method' [12]. The results obtained excel method are checked by ETABS, a commercial program that analyzes by finite element method [13].

2. Material and method

2.1. Masonry buildings modeling methods

Masonry buildings are a heterogeneous building consisting of many parts such as bricks, ashlars, stone and mortar. The behavior of the in-plane masonry walls depends on the piers, spandrels and openings, while the earthquake behavior of the masonry buildings depend on the behavior of the walls and slabs [2]. These units are vertical structural components (piers), coupling horizontal structural components (spandrels) respectively [14]. Typical in-plane collapse mechanisms for piers are given in Figure 1. Out-of-plane collapse mechanism in masonry buildings should be avoided. In-plane behavior of structure completely like a box should be provided [15].

Finite Element Method is generally used for numeric analysis of masonry buildings [17]. It is quite difficult to reflect behavior of earthquake of masonry buildings to model created due to heterogeneity of masonry buildings. In addition, a good estimation of the behavior of the masonry building will allow the development of the building in the construction process [18]. Many different modeling methods have been developed. These model types are as follows [4]:

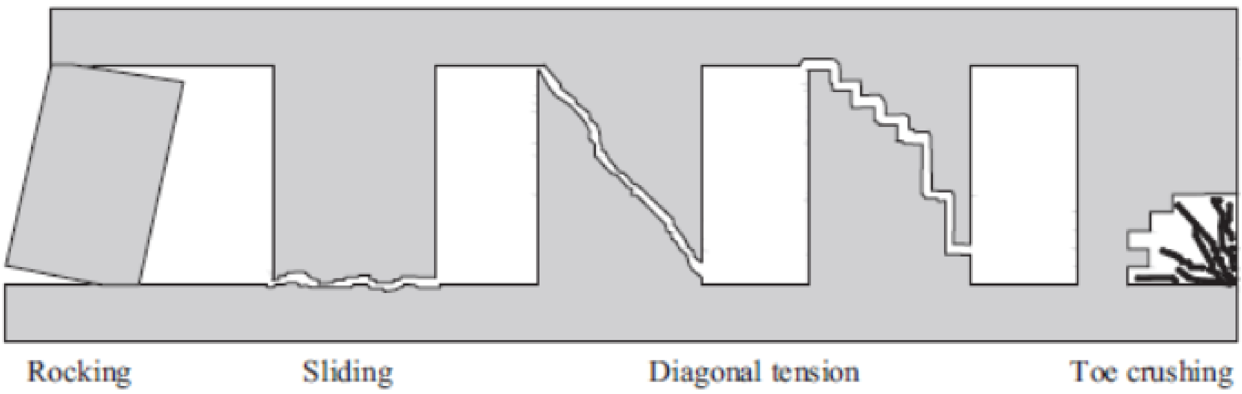

Figure 1. In-plane collapse mechanisms of the piers [16].

Detailed Micro Modeling: It is the type of modeling that the binder and the masonry units (brick, stone, etc.) are independently modeled. A non-continuous surface is defined between the masonry wall unit and the binder. Interaction is achieved with this surface. An example of the model is given in Figure 2a. This model type is used in special cases because it requires a lot of work.

Simplified Micro Modeling: Masonry wall units are modeled. However, the surface between the masonry wall units and the binder is not defined in this method. The bond between the binder and the masonry wall unit is considered to be a continuous surface. The modeling example is given in figure 2 b.

Macro Modeling: The wall is modeled as a whole and as a continuous element taking the average of the mechanical properties of the masonry wall units and the binder [19]. This model type is the easiest to implement model type. This type of model is given in figure 2c.

2.2. Material Properties

Material properties have been determined according to studies in the past years and the TSC-2007. The mechanical properties to be used in the model of construction are taken according to the values given in TSC-2007.

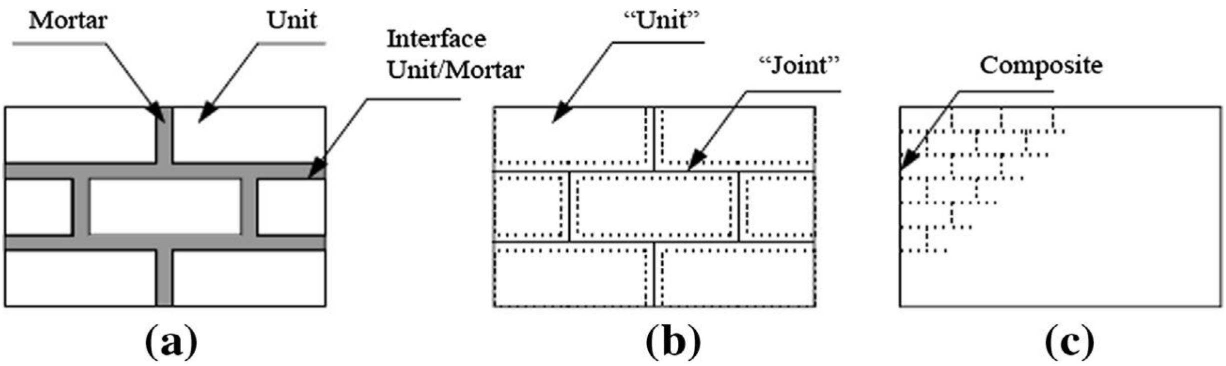

Figure 2. Modelling methods for masonry structures: (a) detailed micro modelling, (b) simplified micro modelling, (c) macro modelling [4]

2.3. Model Creation and Analysis

The building is a existing building located in Konya. The plan of building and the numbers of the walls are given in figure 3. Model of building is created in ETABS by using plan of building and material properties [13]. The material properties used are given in table 1. The earthquake analysis of the building is carried out by using the Mode Superposition Method. The three-dimensional model created in the ETABS program is shown in Figure 4.

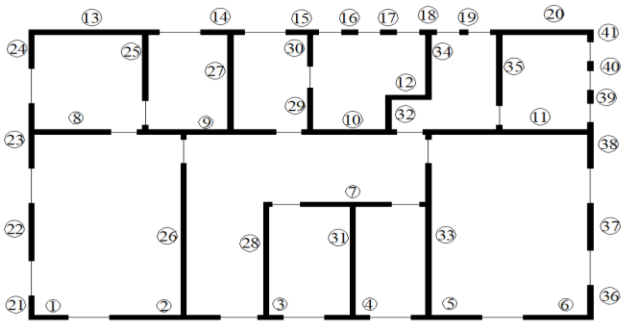

Figure 3. Floor plan and number of walls.

Table 1. Material Properties.

Material Properties	Value
Module of Elasticity	1000 (MPa)
Poisson ratio	0.2
Weight per unit volume	17.65 (kN/m^3)
Cracking Safety Stress of Wall	0.15 (MPa)
Compressive Safety Stress of Wall	0.8 (MPa)

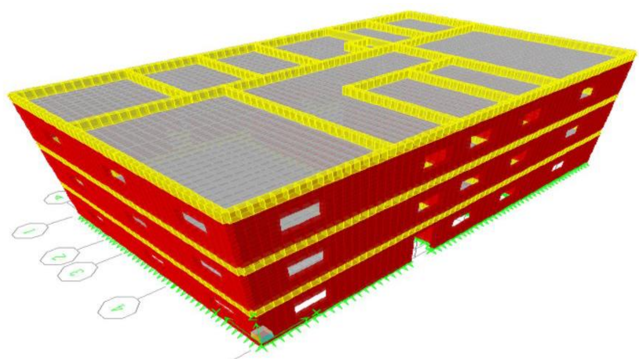

Figure 4. The three dimensional model of the building.

The building is modeled as a finite element. The walls are modeled as a macro model as a shell element. The bond beams on the walls are modeled. It is accepted that the slabs are supported on the bond beams. The wall, bond beams and slabs dimensions are taken as 200 mm, 200x500 mm and 120 mm respectively. The calculations made according to TSC-2007, namely Excel Method, have the same values.

3. Results and discussions

The shear and normal force values formed in the walls in the analyzes are given in Figure 5.

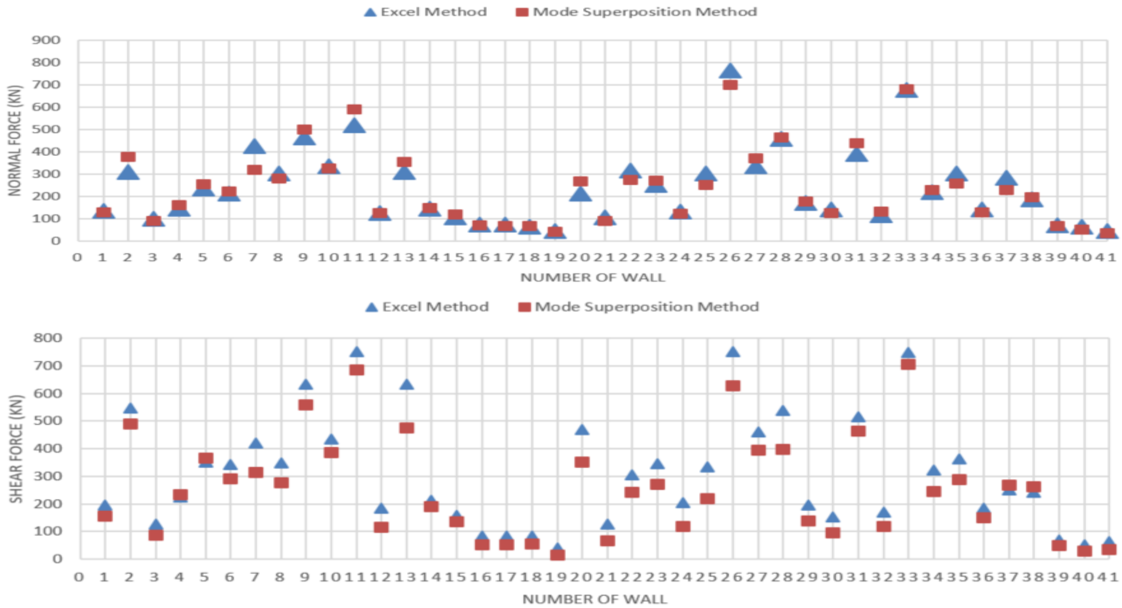

Figure 5. Normal and shear forces acting on walls.

As can be seen in figure 5, while the normal force levels in the walls are close in both methods, shear forces generally yields higher results in the excel method. When excel calculations are defined, it is assumed that the walls below and above the gaps do not carry the shear force. However, in the analysis of the ETABS program, it appears that these walls carry shear forces (Figure 6).

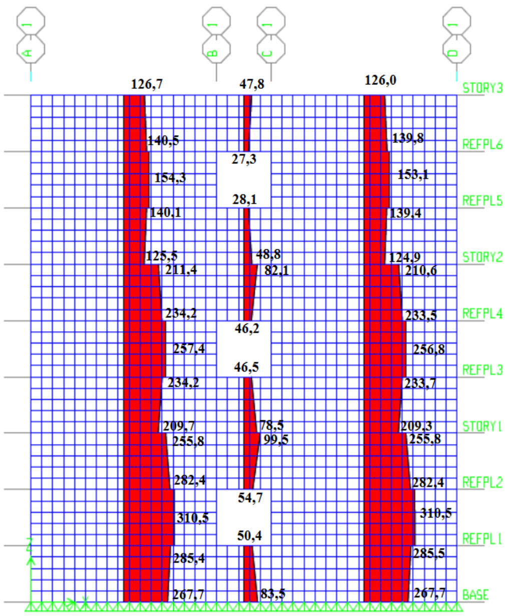

Figure 6. Shear force diagram.

Figure 7 gives the stresses that occur in the walls due to normal force.

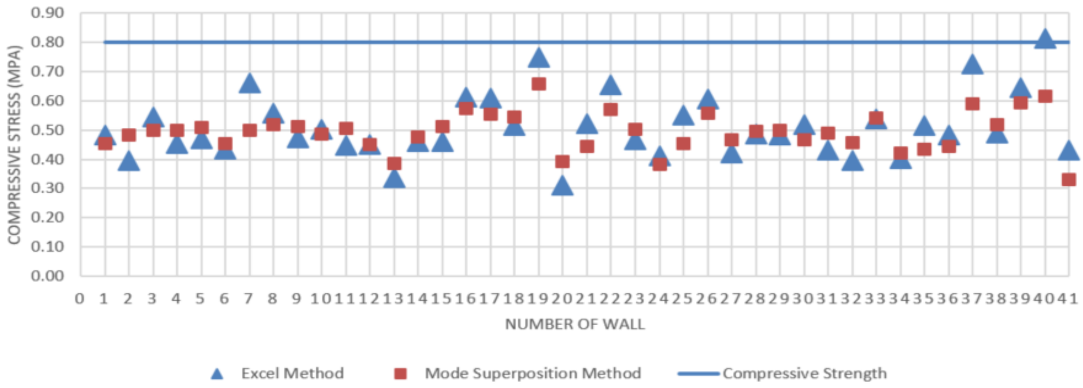

Figure 7. Compressive stresses in the walls.

As can be seen in Figure 7, the walls are generally safe in compressive stress. The resistance against the shear stress of the wall is directly proportional to the normal stress on it. The shear safety stress is calculated by the formula (1) given in TSC-2007 [12].

$$\tau_{em} = \tau_o + \mu\sigma \qquad (1)$$

In this equation τ_{em} the wall shear safety stress, τ_o cracking safety stress of the wall, μ coefficient of friction (it can be taken as 0.5), σ vertical wall stress.

Cracking safety stress of wall is given in Table 2.

Table 2. Cracking safety stress of walls [12].

Type of Masonry Unit and Mortar Used in the Wall	Cracking Safety Stress of Walls τ_o (MPa)
Vertical hallow block brick (hallow rate is less than 35%, with lime mortar supported with cement)	0.25
Vertical hallow block brick (hallow rate is more than 45 %, with lime mortar supported with cement)	0.12
Filled block brick or clay brick (with lime mortar supported with cement)	0.15
Stone wall (with lime mortar supported with cement)	0.10
Gas concrete (with adhesive)	0.15
Filled concrete briquette (with cement mortar)	0.20

The wall shear safety stress is calculated by using formula (1). Shear stresses in the walls are given in figure 8 for both methods.

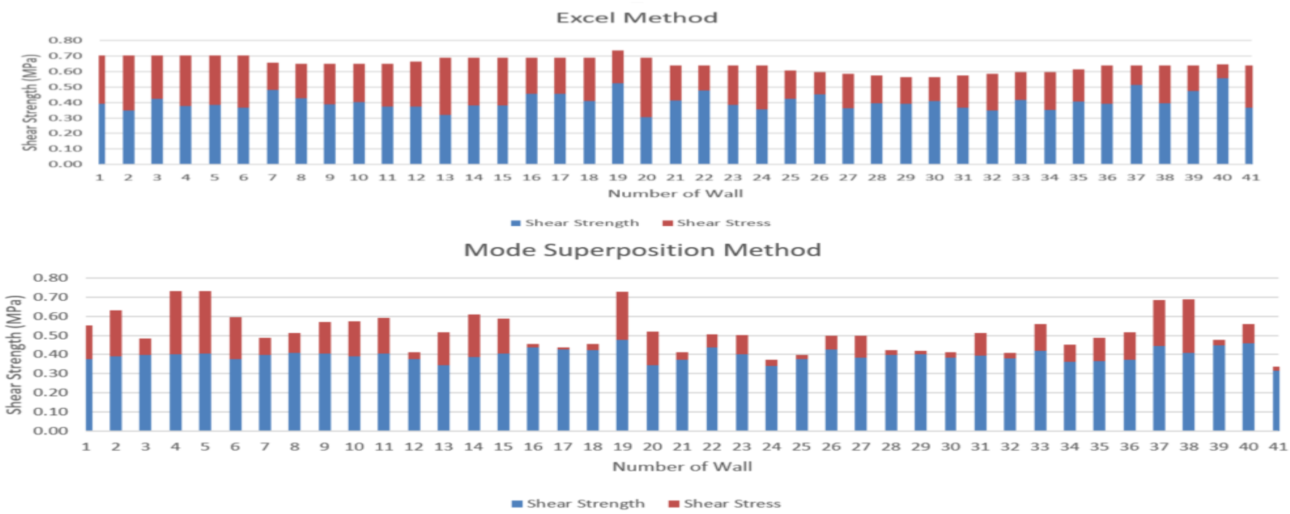

Figure 8. Shear stresses in the walls.

4. Conclusions

An earthquake performance analysis is conducted for two different methods using general material properties of an existing masonry building. The data obtained as a result of the analyzes are shared as graphs. The following results are obtained by evaluating the graphs.

- Although there are no significant differences between the Mode Superposition Method and the Excel Method as normal force, there are very different results in shear force in the two methods.
- The reason why the shear force differs between the two methods is that the walls under and above the door and window spaces actually have shear force. This situation is neglected in the Excel method.
- The building provides adequate safety under vertical loads.
- While the behavior under vertical loads in general is positive in masonry buildings, the main problems arise from behavior under lateral loads. The structure examined also proves it.
- When the shear force diagram obtained in the ETABS program is examined, it is seen that there is shear stresses concentration in the adjacent walls of the gaps.
- The shear stress concentration on the masonry walls leads to damage as shown in figure 9. To avoid this, vertical bond bemas should be used on the edges of the gaps [12].
- The results are getting away truth because the Excel Method is generally slower and has much more assuming.
- More realistic solution is obtained by using Mode Superposition Method due to creating finite element model.
- Macro modeling, which is used in the analyzes, is a preferable method. It is a preferred method for saving time especially in the analysis of building without historical value.

Figure 9. Cutting damage on the wall edge of the gaps [20].

This study is about the specification of open problems to be addressed in the field of MIMO, thus emphasizing the points to be taken into account in achieving the achievements promised by MIMO technology As can be understood from the above difficulties, various complexities need to be removed for implement Massive MIMO systems. The huge increase in traffic market for mobile data services has enabled Massive MIMO to be used in fifth generation (5G) core technologies.

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