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NUMERICAL ANALYSIS OF MASONARY BRICKWALLS UNDER DIAGONAL COMPRESSION LOAD BY ANSYS

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Abstract

Masonry structures are constructed by joining masonry units (brick, stone, marble etc.) with mortar. Various methods are used for modeling of masonry walls of the structures. Micro modeling and Macro modeling are two diverse modeling techniques. In this study, micro modeling strategies are analyzed on a solid unreinforced masonry and textile strengthed masonarty walls numerically. The models are implemented in ANSYS software to simulate the structural behavior of a tested wall in literature.. Brickand mortar are modelled separately in the micro model. Stresses occurring in the walls under the effect of in-plane loads are investigated. The propagations of the cracks on the walls are analyzed numerically. The results obtained in the micro modeling and are in consistent with the experimental study in the literature. However, micro modeling represent strictly disparate behavior in the material identification, and crack propagations.

Keywords: Numerical study, Brick wall, Diagonal loading

INTRODUCTION

Masonry structures It is built by bonding materials such as natural stone, brick, aerated concrete together with mortar. Masonry structures have existed for many years and still

1. continue to do so. There are many important historical masonry structures such as palaces, bridges and mosques, which are considered as cultural heritage in our country, which has hosted many civilizations in the world. Important historical buildings like this one Due to uncertainty of strength, unknown earthquake behavior, natural disasters,

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human factors, ground and environmental conditions, physical and chemical effects, historical textures are in danger of being damaged or evendestroyed [1]. In addition to the important historical masonry structures in our country, there are also many masonry structures built in violation of engineering rules. When the structural systems of the buildings are examined according to the 2000 census of the State Institute of Statistics (DIE), more than 50% of them appear as masonry structures [2]. There are many experimental and numerical studies about understanding the structural behavior of masonry structures and strengthening existing masonry structures. In this study, micro modeling strategies are analyzed ona solid unreinforced masonry and textile strengthed masonarty walls numerically. The models are implemented in ANSYS software to simulate the structural behavior of a tested wall in literature.. Brick and mortar are modelled separately in the micro model.

MODELING OF MASONARY

The main goal in modeling is to produce a model that behaves close to the real structure. The modeling of the masonry walls requires more care than other constructions because of the different characteristic of the masonry units and mortar. Various methods are used in the modeling of masonry structures. Masonry structures can be generally modelled as heterogeneous and homogeneous models. Detailed micro and simplified micro models are heterogeneous models. Macro modeling technique is known as homogeneous modeling technique.

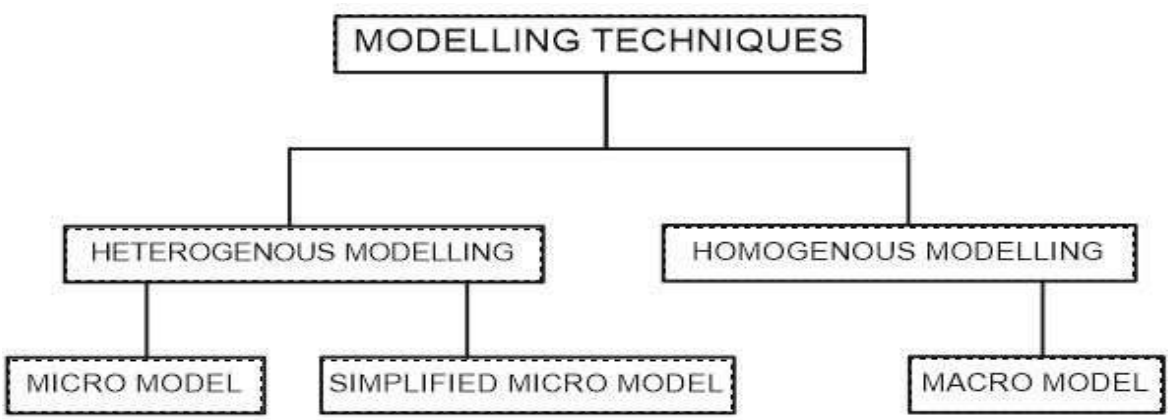

Figure 1. Modeling techniques for masonry walls

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Micro Modeling

In micro technique, masonry units (brick, stone, etc.) and the mortar are modelled separately. Interfaces in the joining areas of these elements can be also included in the model. The micro modeling is shownin Figure 2. Although modeling of structures with micro modeling technique is a detailed process, localbehavior of the structures can be investigated wit this technique.

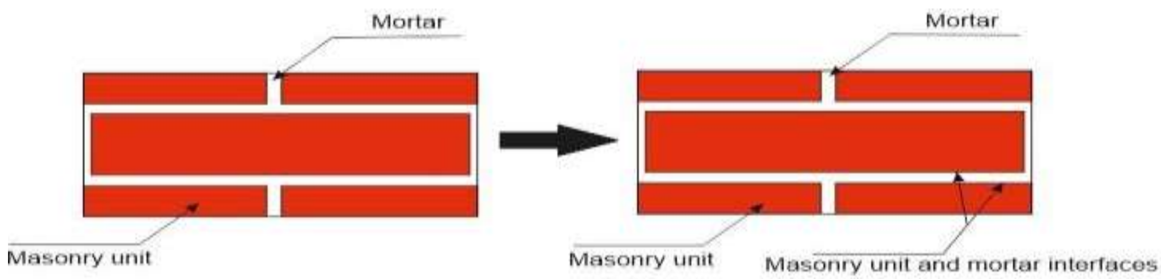

Figure 2. Micro modeling procedure

FINITE ELEMENT MODELS OF MASONRY WALLS

The model, based on the micro-scale approach, was created in ANSYS 2021. The mesh of the model was done following three main stages: firstly, the half brick was created with interface elements to represent the brick crack and the brick joint, then the basic brick was duplicated in order to create the two-brick model with all the interface elements required for simulation. Lastly, the two-brick model was replicated in horizontal and vertical direction in order to achieve the required dimensions of 1 x 1 m. SOLID 65 finite elements in the ANSYS software was used for the finite element analysis. This element has 8 node points and each node point has 3 displacement degree of freedom in x, y and z directions. It can show collapse mechanisms both tensile and compression. Brittle materials can be modelled such as rock, stone, brick, concrete etc. This element is suitable for modeling of nonlinear behavior of structures and cracks can be determined in the structure. The structure of the SOLID 65 element is shown in Figure- 3.

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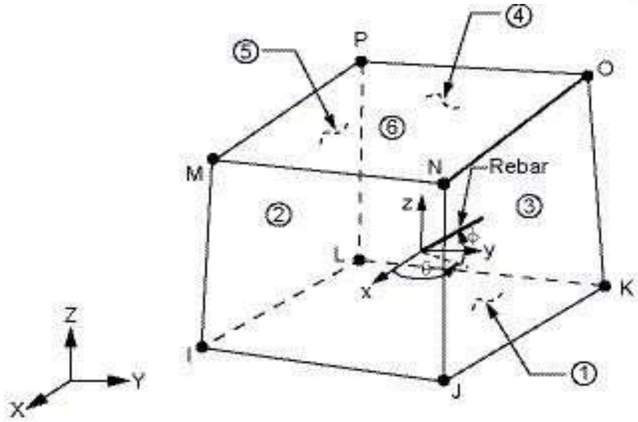

Figure 3. SOLID 65 element

Material parameters used in the models are shown in Table 1. Brick and mortar material parameters were implemented to micro finite element model.

Table 1. Material properties

Material	E($\frac{kn}{cm^2}$)	υ
Brick	200	0.15
Cement mortar	70	0.2
Wire steel	3266	0.25

Table 2.Wire steels Properties

WALLS	Name	Thickness(mm)	Bolt space(cm)
WALL1	Reference	-	-
WALL2	MBW 3-400	3	40
WALL3	MBW 1.5-150	1.5	15
WALL4	MBW 2-150	2	15
WALL5	MBW 3-150	3	15

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In the numerical analysis, the Willam-Warnke fracture hypothesis is used for nonlinear behavior of the masonry wall. Three-dimensional fracture surface and two-dimensional fracture surface for WillamWarnke hypothesis is shown in Figure 4. Willam-Warnke hypothesis is a suitable hypothesis for materials having different compressive strength and tensile strength such as masonry materials. Masonry materials usuallyhave high compressive strength and low tensile strength.

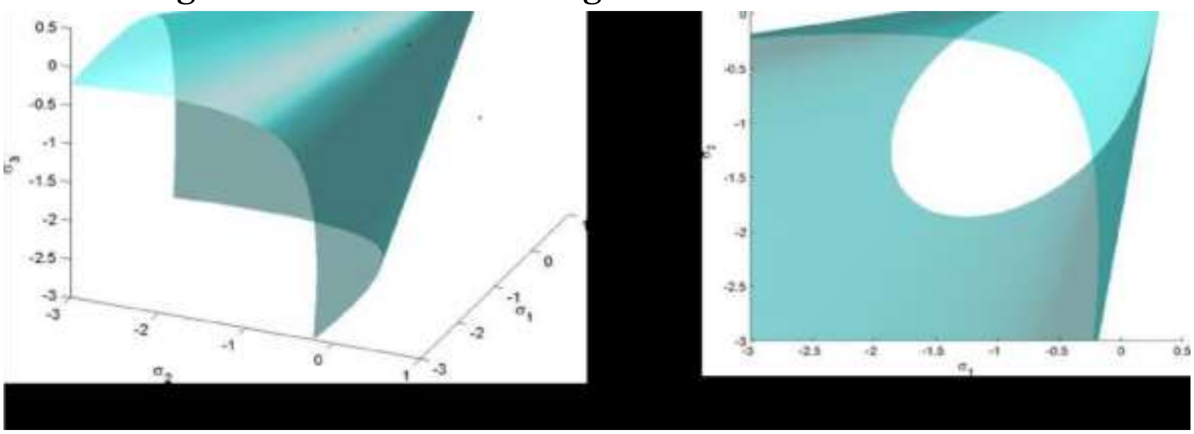

Figure 4. Willam-Warnke fracture surfaces: (a) Three dimensional space (b) Two dimensional plane

Micro Finite Element Model

Geometry of the model and finite element mesh were produced with the micro modeling technique. In this technique bricks and mortar are modelled separately. For meshing used sweep mesh for bricks andfree mesh for cement mortar and steels. Figure 5 and 6 indicates the geometry and the finite element mesh of the micro model.

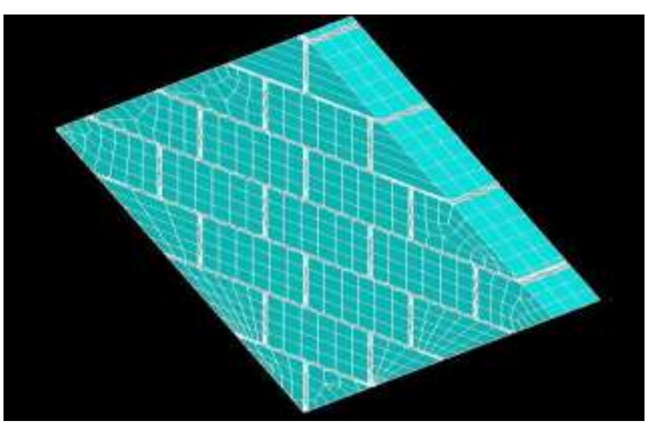

Figure 5. Wall1 after meshing

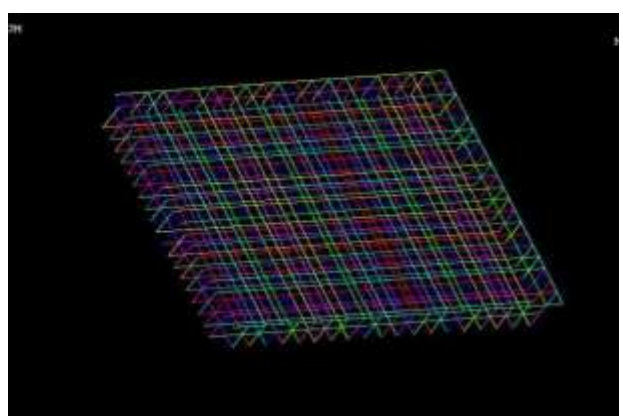

Figure 6.Steels mesh

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Deformation of walls under ultimate diagonal loading for reference and strengthed walls with differentsteel mesh thickness are shown in Figures 7,8,9,10,11.

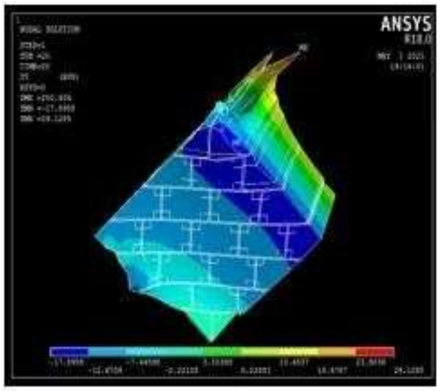

Figure 7. Deformation Reference wall

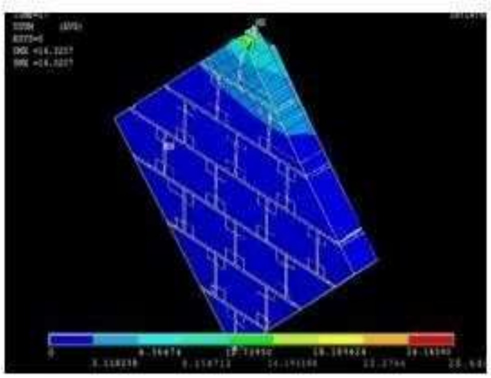

Figure 8. Deformation of MBW 3.0-400

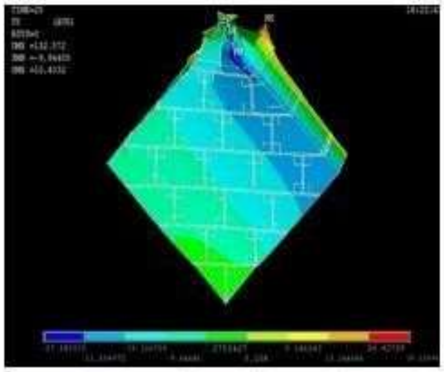

Figure 9. Deformation of MBW 1.5-150

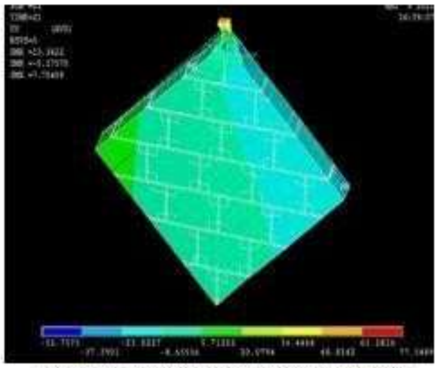

Figure 10. Deformation of MBW 2.0-150

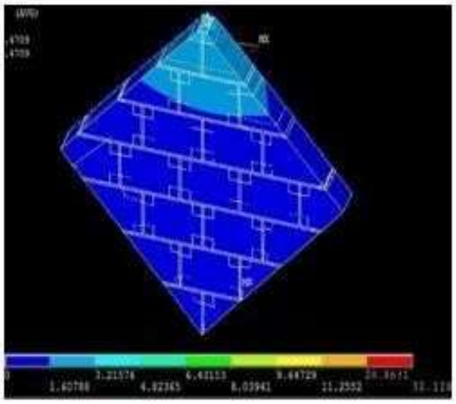

Figure 11. Deformation of MBW 3-150

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RESULTS AND DISCUSSION

In this study, an unreinforced masonry wall strengthed masonary walls were modelled and analyzed using finite element method. The proposed model was implemented and applied to the five walls presented in the litru. The parameters related to geometry are taken from the information given previously, as wellas some other information related to the properties of the materials. The compare results of micro modeling and experimental walls are showed in Table 7.

Table 3. Main results for numerical and experimental walls

WALLS	Maximum load (kn) inANSYS	Deformation(mm)in ANSYS	Maximum load (kn) in experimental	Deformation(mm)in experimental
Wall refrence	96	29.1	99.85	25.9
Wall MBW3.0-400	150	28.6	147.02	25.3
Wall 1.5-150	157	77.5	154.65	65.40
Wall MBW2,0-150	159	30.1	161	34
Wall MBW 3-150	155	32.1	160.5	36.75

4.1 Experimental vs Numerical comparisons

In this section a comparison between experimental and numerical results is discussed. The ANSYS modeling was compared with the test results and the behaviour had been observed. The numerical load versus displacement and compared with the experimental results were shown in Figure 12. Review of the numerical data leads to recognize that, if micro-modeling strategy was applied, the overall response of the masonry panels can be well predicted in terms of the collapse load and the deformation values as well as sufficiently accurate failure mechanisms can be predicted.

At the end of the results, it may be concluded that the strengthening technique provided the best results in terms ofboth load and deformation, making the panel more resistant against diagonal compression loads.

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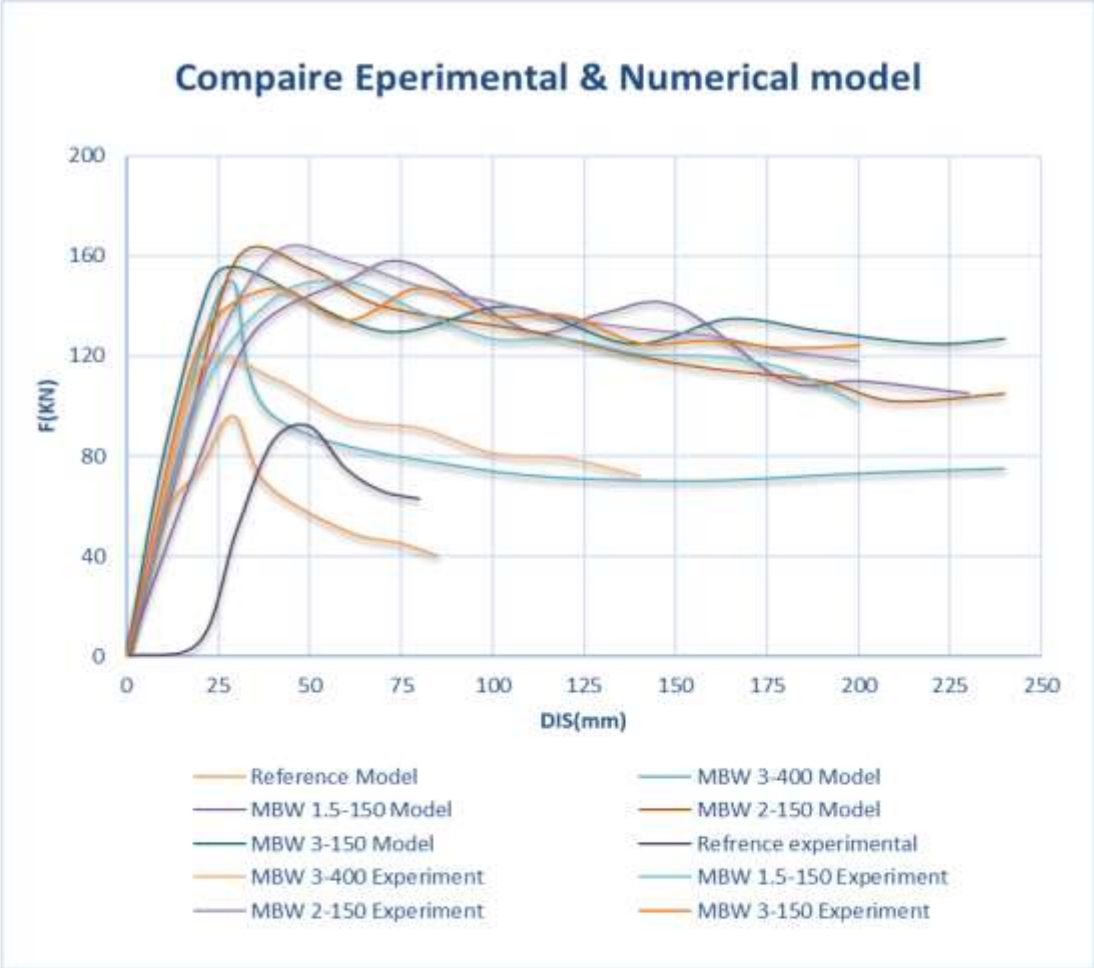

Figure 12 Comparative Load-Displacement Curves of All Model and All Experimental wall Samples

CONCLUSIONS

The study presented has shown that existing commercial software (such as ANSYS or other similar software) can be used to effectively model complex use of masonry walls. The numerical simulations calculations carried out in the present research have contributed to enhance the understanding of the structural response of the unreinforced and TRM-strengthened masonry walls subjected to diagonal compressive loading conditions and the results of numerical micro modeling masonary brick walls under diagonal loading show us good agreement between ANSYS results with experimental results from the results of numerical simulations work the following conclusions can be drawn:

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1) Numerical analysis showed that technique provided more satisfactory results in terms of higher resistance and more ductility levels.
2) The development of a unique finite element modelling strategy, which was designed to explicitly model the reinforcement mechanism of the TRM reinforcement.
3) In depth analysis on failure modes and reinforcing mechanisms of TRM strengthened masonry wall panels using the combination of experimental results and advanced finite element modelling.
4) From this study it is concluded that within short period of time complex structure
5) analysis can be performed which take longer time experimentally. Different material properties can be easily assigned to model and their change in behavior can be found out.
6) Also the crack pattern of the masonry structure can be identified using this numerical study
7) The numerical model showed good agreement with the results of the laboratory tests.

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