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Performance Evaluation of Unconfined masonry Infill walls

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Abstract—***Infill walls are very common structure present around us but their significance was always overlooked leading to the premature collapse of building during the laterals loads such as earthquake and wind loads. After many drastic failures of masonry buildings, civil engineers try to find the answer for the failure of these buildings. Later, studies show that the infill walls plays an important role when the lateral loads are applied on to the structure.***

Engineers also found that it is very difficult to conduct experimental studies by changing different parameters of the infill walls. So, researchers have been finding other simpler methods to analyse the infill walls to get the actual behaviour of the structure under lateral loading. This leads to the formulation of numerical modelling so that the behaviour can be easily analysed by simply changing the parameters as well as the material properties.

Studies later revealed that, provision of infill generally improves the lateral stiffness, energy dissipation of the structure and also lateral load carrying capacity of the structure as a whole. They also found out that there are different parameters like openings in wall, height of infill wall, boundary conditions of infill wall with the frame, etc. can affect the seismic performance of the structure.

Keywords— Masonry infill walls, micro-modelling, failure mechanism, lateral loads..

I. Introduction

Infill walls are common elements present in buildings. Infill walls are mainly provided in between the moment resisting frame after the construction of the structural skeleton as shown in Fig.1

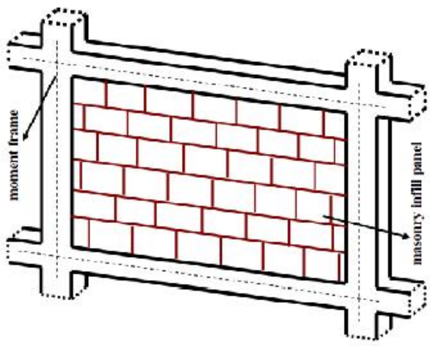

Fig. 1 Masonry infill walls (Dilmac et al., 2018)

The main function of infill walls is to provide privacy and to have better space utilization. Commonly clay bricks, hollow bricks, autoclaved aerated concrete (AAC) blocks, etc has been used as infill masonry units. The supporting frame may be of reinforced concrete or steel structure.

Earlier days, the role of infill walls was neglected, but after many earthquakes they have found that infill walls plays an important role in determining the failure criteria of the structure. So, engineers started studying the behaviour of infill walls subjected to lateral loads. Since there are different changing parameters involved in the infill walls, experimental studies were not feasible. This resulted in creating different numerical models to study the behaviour of infill walls. Numerical analysis can be done in different methods like equivalent diagonal strut method and continuum method.

In equivalent static method, we are reducing the infill wall into a diagonal compression member. It is an approximate method of analysis. In continuum approach, we make use of a finite element package to model the whole building. This is the most accurate method. In this method itself we can model in 3 different ways:

- Detailed micro-modelling: In this method all the elements are modelled using special elements and after analysis we will get the complete failure mechanisms of the structure.

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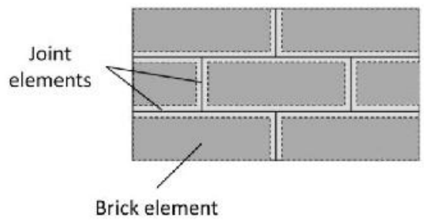

Fig. 2 Detailed micro-modelling (Campbell and Duran, 2017)

- Simplified micro-modelling: In this, the bricks are modelled as special elements available in any finite element software package. But the mortar interface is modelled as a contact element. Since the mortar joint between the bricks are modelled as contact elements, Poisson's ratio of the mortar is neglected in this approach

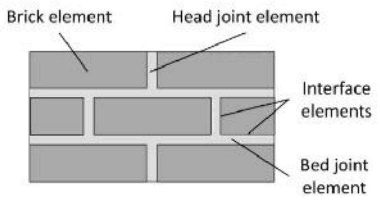

Fig. 3 Simplified micro-modelling (Campbell and Duran, 2017)

- Macro-modelling: In this method, we are converting the whole structure into a single unit. Here we will be defining the failure criteria for the material and the analysis result with be an approximate one. This is the simplest type of analysis.

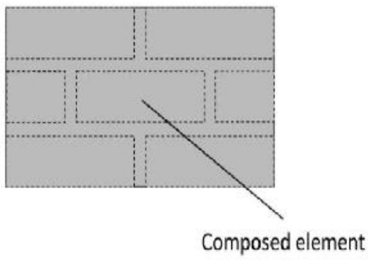

Fig. 4 Macro-modelling (Campbell and Duran, 2017)

Nowadays infill walls are also considered as an important member in the design phase itself so that we can eliminate any premature collapse of building and prevent loss of life during lateral loadings.

II. Literature Review

A. *Influence of masonry infill walls on seismic performance*

Keyvani and Farzadi (2011) studied the influence of infill walls on seismic performance of the frame using ANSYS. Results shows that ductility of the frame is dependent on the height up to which the masonry is provided and they had found out that only in frame with infill walls up to the total height resulted in improving the ductility. They had also found that infilled frame improves the lateral stiffness of the building compared to that of a bare frame.

Tamboli and Karadi (2012) studied the influence of infill walls during the earthquake loads using ETABS. Infilled frame was modelled as an equivalent compression strut. Different parameters like base shear, storey drift, time period of oscillation of the building were investigated and found out that the infilled frame decreases the storey drift and time period of oscillation of the building compared to the bare frame. Also, the most practical case of open first storey was investigated and found out that the storey drift of the first storey was much higher than that of the bare frame as well as the infilled frame.

Campbell and Duran (2017) studied the possibility of developing a numerical model to accurately interpret the in-plane behaviour of the masonry walls under seismic loads in ANSYS. They had taken a simplified micro modelling approach in which the mortar joints were assumed as linkage elements. Results showed the comparisons of the push over analysis of the infill walls with that of the values already available.

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Thomas and Kuriakose (2016) studied the behaviour of the unreinforced masonry using ANSYS. They had done a macro -modelling in which they had reduced the masonry as a single homogeneous unit and the parameters were defined to make the unit behave nonlinearly when load is applied. They had found out that with the increase in length as well as the width of the infill wall, the load carrying capacity of the structure is also increased.

Kumbasaroglu et al., (2017) studied the influence of bond slips between the infill wall and frame. For this they had done experiments on a bare frame, infilled frame with anchor bars and infilled frame without anchor bars. Results shows that the infilled frame with the anchor bars resulted in higher lateral strength, energy dissipation than the others. They had also found out that the displacement due to bond slippage of reinforcement bars resulted in nonlinear behaviour of frame.

Dilmac et al., (2018) studied the seismic performance of existing buildings with and without infill wall using SAP 2000. They had considered the non-linear behaviour of concrete and the infill walls were designed as nonlinear strut elements, so that accurate results can be obtained. The results shows that if the infill walls are distributed uniformly, they can improve the performance of the building against the lateral loads. They also found out that the presence of infill walls resulted in increase in lateral stiffness, strength and energy dissipation compared to a bare frame.

Okasha et al., (2020) studied the effects of autoclaved aerated concrete (AAC) blocks as infill wall material on the seismic performance of the building using ETABS and ANSYS. A model with anchor bars protruding from the frame to the masonry was also studied. Results shows that infill wall made of AAC blocks resulted in not only reduce the dead weight of the building but also out performs clay blocks in terms of in-plane stiffness and the reduction in storey drift. They have also found that the model with anchor bars resulted in reduction in displacement of the structure and increase in the failure load.

Pallares et al., (2021) studied the effect of masonry in determining the seismic behaviour of the building. Based on the experimental data a more simplified macro model was developed for the future study. Results shows that the masonry infill walls increase the stiffness of the building as a whole and also helps in reduction of fundamental period of oscillation.

B. Influence of height of masonry walls on its performance

Guevara and Garcia (2005) studied influence of height of the masonry infill wall on the failure behaviour of the structure during the earthquake loads. They had found that the provision of masonry infill walls up to the total height resulted in increasing the lateral stiffness of the structure and there by resulting in a more predictable failure pattern of the building frame whereas by providing the infill wall only up to a certain height resulted in developing higher force on the column region which s not laterally supported and thereby resulting in short column effect

III. RESEARCH METHODOLOGY

The behaviour of masonry walls is complex when an earthquake is acting upon it, so doing many iterative experiments to generalise the findings is a much more complex procedure. So, a numerical modelling is better suited in this situation.

The project is done on a finite element package called ANSYS. Here the base of the masonry wall is fixed and the force is applied on the top face and the corresponding top displacement is measured.

Here we are inputting the material parameters and we will be modelling the infill wall. Various parameters like height, length and thickness of wall are changed and the comparison between these results were done.

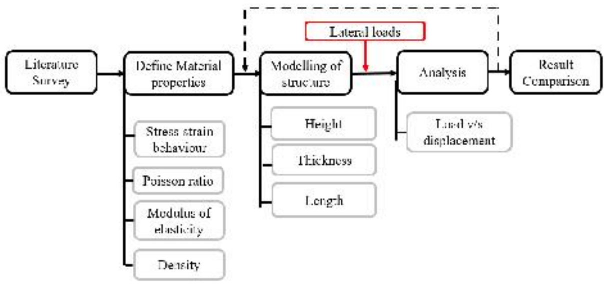

Fig. 5 Workflow

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In this paper we are doing the macro-modelling setup. In which we have inputted the stress strain behaviour of the masonry as a whole from Kaushik et al., 2007.

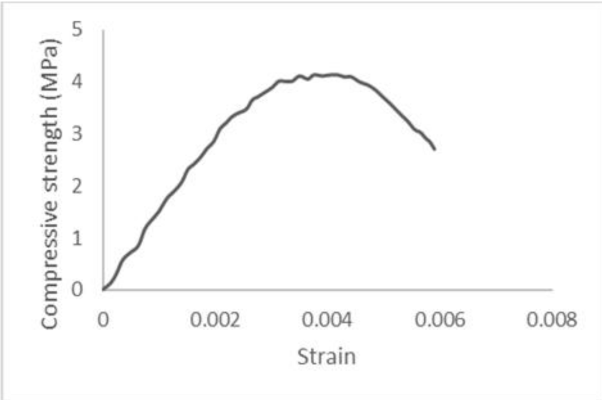

Fig. 6 Stress strain relationship of brick masonry (Kaushik et al., 2007)

The material properties of the masonry are defined in Table below.

TABLE I. MATERIAL PROPERTIES OF MASONRY

Material Properties	**Values**
Density	1920 kg/m^3
Poisson's ratio	0.25
Elastic modulus	1454.6 MPa

Most of the masonry walls for residential houses will be between 1.50 m and 4.00m and the height will be normally 3.00 m or 2.10 m and the thickness will be 0.10m or 0.20 m.
Details of the models are shown in the Table below.

TABLE II. NUMERICAL MODELS

Length (m)	**Height(m)**	**Thickness(m)**	**Designation**
1.80	3.00	0.10	1.8*3*.1
1.80	3.00	0.20	1.8*3*.2
1.80	2.10	0.10	1.8*2.1*.1
1.80	2.10	0.20	1.8*2.1*.2
2.50	3.00	0.10	2.5*3*.1
2.50	3.00	0.20	2.5*3*.2
2.50	2.10	0.10	2.5*2.1*.1
2.50	2.10	0.20	2.5*3*.2
3.00	3.00	0.10	3*3*.1
3.00	3.00	0.20	3*3*.2
3.00	2.10	0.10	3*2.1*.1
3.00	2.10	0.20	3*2.1*.2

The output parameters that are measured are the lateral load versus displacement when subjected to lateral loads.

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IV. RESULTS AND DISCUSSIONS

A. Load - displacement curve

First, we have fixed the height as well as the thickness of the wall and the length is changed so as to study the influence of length of the wall on the lateral load carrying capacity. Fig. 7 shows the plot between the lateral load and the top displacement.

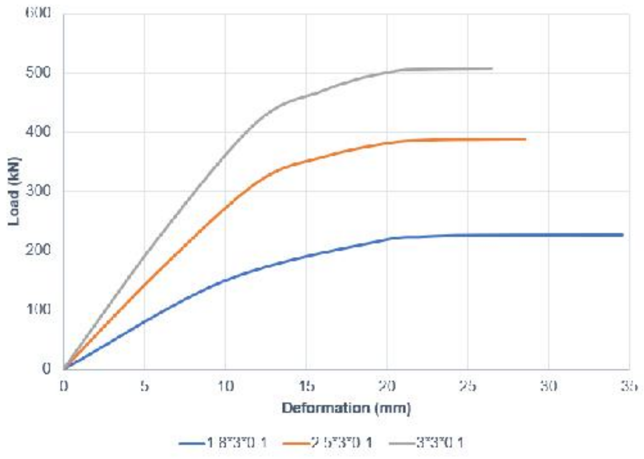

Fig. 7 Load displacement curve showing influence of length of wall

From the above figure it is very much clear that as the length of the wall increases, the load carrying capacity has also improved drastically. This is because as the length is increased the lateral stiffness of the wall is improved, so it will be requiring higher loads for smaller displacement.

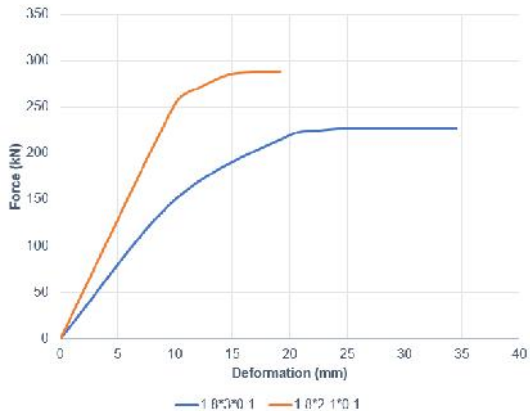

Fig. 8 Load displacement curve showing influence of height of wall

To study the influence of height of the wall, we have fixed the length (say 1.80m) and thickness (say 0.10m) and the height is changed. Fig. 8 show the plot between the load and the top displacement.

From Fig.8 we can see that as the height of the wall decreases, the lateral load carrying capacity of the wall is improved. The whole masonry wall is similar to a cantilever beam so, as we know if the span is more then the load required to deflect the beam will be less.

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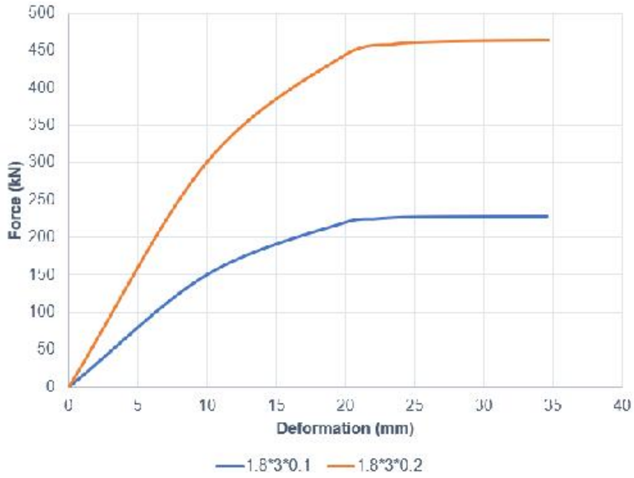

Fig. 9 Load displacement curve showing influence of thickness of wall

Finally, to study the effect of thickness of the wall on the load carrying capacity, we have fixed the length as well as the height of the wall and the thickness of the wall has been changed.

From Fig. 9 we can observe that as the thickness of the masonry wall is increased, the lateral load carrying capacity of the wall has been improved. This is because as the thickness is increased the section modulus of the wall is increases making it sufficiently strong enough to resist higher lateral loads.

V. CONCLUSION

This paper formulates a numerical evaluation of unconfined masonry infill wall subjected to lateral loads. The findings of this study is limited since we have done a macro-modelling technique.

Through this study we have found out that increase in length as well the thickness of the wall improves the lateral load carrying capacity and the increase in height of the wall decreases the load carrying capacity of the wall. analysis of Future studies using micro-modelling has to be done to study the actual behaviour of the wall subjected to lateral loads.

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