Analysis of Infilled Masonry Wall in Steel Frame Subjected to Lateral Loading by Experiment and FEM Software.

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Abstract. This paper describes the behaviour of infilled masonry wall in steel frame subjected to lateral loading. Construction of RCC structure is quite slower than Steel structure, though the cost of steel structure is high but time required for construction is less, moreover for temporary structure steel member and section are use on large scale as it can be reused also. In this study a rectangular steel frame of IS section ISMC 250 is made and lateral loading is applied through jack. Frame is infilled by fly ash units with thin mortar joint. Axial load is also applied on frame simultaneously, during experiment and data is analysed, same full scale model is simulated in FEM tool and result were compare and found that they valid each other, it was observed that in steel frame initially bond between masonry and steel frame section get separated and it try to overturn the masonry wall from toe and debonding at toe initiated but as it is bounded and lock in channel section it stress transfer to heel side of masonry and all stress is concentrated on heel and heel crushing take place.

1. Introduction
Over the last year, the use of confined masonry for low rise structure has increased in developing countries like India. due to confinement its stiffness increases and enhance the performance of the structure in lateral loading or any dynamic loading such earthquake, wind load or in cyclonic loading. Considering they mechanical behaviour of masonry wall as it is intact to column and does not get separated as infilled wall. It helps in carrying lateral and axial load this type of wall is also consider as load bearing wall. In this type of construction wall is cast prior to column and the with the help of tooth action column and wall is made monolithic. As many low-rise buildings made in this way has shown better performance during earthquake in many places.

In tall and slender wall shear crack and diagonal crack failure is pre dominant in lateral loading [4] Number of experimental approaches are adopted to test the masonry wall, such as Prism test, Diagonal compression test of single brick. Generally, prism of 4 to 5 bricks and diagonal compression test of side distance 1 m to 1.2 m. [10]

2. Numerical modelling
Masonry is non linear material, as failure criteria is influencing factor while modelling masonry in FEM tool. There are few approaches made by researchers and they found that some failure criteria satisfy the model failure and validation with experimental results. Concrete Damage Plasticity model is also reliable modelling technic and results are close to real experiment results. In this research micro modelling technics is adopted [12]. Drucker Prager model with expanded XFEM is also showing accurate results to actual existing experiment. [13] There are various modelling strategies adopted as
mention below in figure 1. Detail Micro Modelling 2. Simplified Micro Modelling 3. Macro modelling or composite model. In this current study Macro Modelling/ composite modelling is been used to analysis the masonry wall infilled in steel frame.

**Figure 1.** (a) Detail micro modelling (b) Simplified micro modelling (c) macro modelling or composite modelling.

From figure 1 simplest composite model is selected such that the model is homogenous and in which total strength of brick and mortar is considered. This type of modelling is time saving fast and good predictable analysis, where the chances of failure and stress are going to exceed beyond the limit. Can be easily obtained. But this type of modelling is less accurate compare to micro modelling. In this experiment, steel frame of Section ISMC 250 and each unit of size 600mm X 200mm X 100 mm were used as shown in figure 2.

| Material            | Dry Density | Compressive strength | E (Modulus of Elasticity) | Poisson ratio |
|---------------------|-------------|-----------------------|---------------------------|---------------|
| Fly Ash Blocks      | 650 kg/m³   | 4.5 N/mm²             | 2090 MPa                  | 0.15          |

### 3. Experimental setup
Axial load and lateral load are applied through jack which is attach to frame. Frame is made up of Channel section ISMC 250 and bottom two support are hinge support and top two joint are Pinned joint as shown in figure 2. Table 1 shows the mechanical properties of bricks which were used in modelling.

**Figure 2.** Experiment setup for testing infilled wall.
Figure 3. Experiment setup bare frame infilled wall.

(a)  

(b)  

Figure 4. (a) Experiment setup and load measuring device. (b) failure at toe and heel due to axial and lateral loading.

The details of experimental setup are shown in figure 3. The arrangement of loading and pressure measuring devices and failure pattern of axial and lateral loading are shown in figure 4. However, figure 5 shows the failure pattern at toe and the crushing at heel due to combine axial and lateral loading.
Figure 5. (a) Failure at toe. (b) Failure heel due to axial and lateral loading.

4. FEM Analysis

Figure 6 represents the stress contour after applying axial load, whereas figure 7 shows the stress contour after applying lateral load only. The stress contour of full-scale model developed in FEM software with combine axial and lateral load is shown in figure 8. The obtained FEM results were compared with experimental results, which were in agreement.

Figure 6. Von mises stresses when axial load is applied.  
Figure 7. Von mises stresses when lateral loading is applied.
Figure 8. Von mises stresses when lateral load and axial load is applied simultaneously.

5. Conclusion
Significant work has been done on the analysis of masonry wall using FEM Tool. Moreover, experiment is also done to validate the FEM results.

- Above study shows that homogeneous material considering is also a better approach to know the behaviour of masonry wall.
- Using FEM based software can reduce your experimental effort and gives accurate results.
- FEM based Software saves time, and number of variation and combination can be check and analysed.

6. References
[1] Zampilli, M., & Salerno, G. (2019). 5 th International Conference on Structural Health Assessment of Timber Structures The Borbone ’ S System : A Multiscale Model For The The Borbone ’ S System : A Multiscale Model For The Building Seismic Analysis, (September).
[2] Sousa, L., & Monteiro, R. (2018). Seismic retrofit options for non-structural building partition walls: Impact on loss estimation and cost-benefit analysis. Engineering Structures, 161(November 2017), 8–27.
[3] Silva, L. C., Lourenço, P. B., & Milani, G. (2017). Nonlinear Discrete Homogenized Model for Out-of-Plane Loaded Masonry Walls. Journal of Structural Engineering, 143(9), 04017099. https://doi.org/10.1061/(ASCE)ST.1943-541X.0001831
[4] Rahman, A., & Ueda, T. (2016). In-plane shear performance of masonry walls after strengthening by two different FRPs. Journal of Composites for Construction, 20(5). https://doi.org/10.1061/(ASCE)CC.1943-5614.0000661
[5] Pandey, B. H., & Meguro, K. (2004). Simulation of brick masonry wall behavior under in-plane lateral loading using applied element method. 13th World Conference on Earthquake Engineering, Vancouver, BC, Canada, August, (1664), 1–6.
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