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Experimental And Numerical Study On Cyclic Behaviour Of Infilled Masonry Wall Confined In Steel Frame

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Abstract

A brick masonry wall is one of the most ancient construction techniques used to build buildings. But nowadays, more focus is on sustainable development and fast construction. Fly ash bricks are used widely in construction. For rapid construction, steel structures are used on a large scale. So, in this paper, we have studied the behavior of infill masonry walls made up of fly ash bricks and cement mortar confined in steel frame by applying in-plane cyclic loading to the infill masonry wall. Moreover, the Same model is modeled in FEM-based software (Abaqus). The cracks pattern was observed, and it highly validates the experimental results. The concrete damage plasticity model was used to model the brick masonry in the FEM model. This study investigates the behavior of masonry walls with 1:3 mortar proportion used in brick masonry, i.e., 1:3, 1:4, and 1:6 (Cement: Sand). And it is observed that if strong mortar (1:3) is used, cracks try to propagate through both bricks and mortar joints. And if weak mortar (1:6) is used, generally separation of mortar and brick joint is observed.

Keywords: Masonry Mortar, Cyclic in – plane laod, Steel Frame, Finite Element Analysis.

1. INTRODUCTION

Masonry walls have been used in construction from the ancient period, and they play an essential role in the Behavior of Reinforced Concrete (RC) or steel structure infilled panel/wall. It changes the complete behavior of frame structure. When masonry wall is considered, and as per the observation of day-to-day life, different types of crack are seen on an infilled masonry wall. Which indicates different types of loading acting on the wall, kind of workmanship, quality of material used during construction, and structure behavior can be identified by the crack pattern in the wall if observed correctly. Our Present seismic code (e.g.-IS:1893, Eurocode 8) and design practice do not consider the interaction of infill masonry wall and structural member (e.g., Beam & Column). Due to inadequate research in this area [1]. Over the decades, many researchers from the field of structural dynamic, blast engineering, and seismic engineering have performed many experimental and Simulation studies to evaluate the behavior of infilled masonry and frame structures [2-4].

2. EXPERIMENTAL PROGRAM

The material used in the preparation of brick prism test and full-scale masonry wall, one type of fly ash made brick and three type of mortar with different proportion. (strong (1:3), intermediate (1:4) and weak (1:6)). The bricks used here had dimension 230 x 110 x 75 mm. bricks were soaked in water for a day and were dried after that at room temperature for few hours, before casting prism and construction of wall. compressive strength of brick was 8 MPa. Three type of mortar were selected, to study the effect of mortar strength on behavior of masonry.

2.1 Specimen Preparation

The masonry's compressive strength and modulus of elasticity were determined using tests on masonry prisms with a total height of 420 mm as specified by IS:1905-1987(1998). The assembled specimen must be at least 40 cm tall with a height-to- thickness ratio (h/r) of at least 2 but not more than 5. The Compressive Strength of Masonry Prisms was tested according to the Standard Test Method as shown in Figure 1. and Figure 2.

Figure 1. Prism Specimen Casted

Figure 2. Prism Specimen Tested

Figure 3. Failure of Specimen.

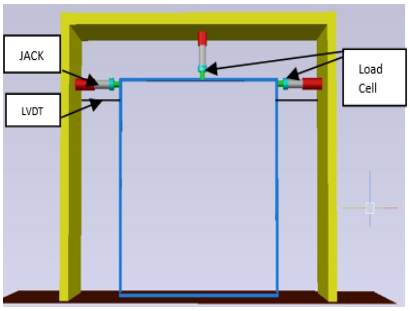

Figure.4. Schematic Diagram of Loading Frame of Cyclic Load Test on Masonry Wall

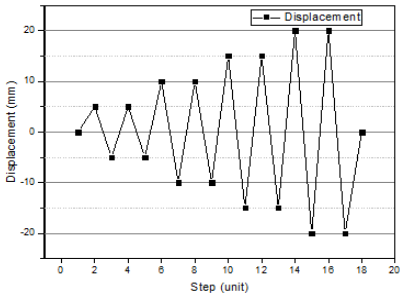

Figure 5. Actual Testing Photograph and Assembly of Testing.

Figure 6. Cyclic Loading Protocol

2.2 Instrumentation and Test Setup

Masonry prism were tested in Universal testing machine by following all the standards. 3mm thick plywood sheet were placed on top to ensure the even load distribution on prism and test were carried out and result were extracted. Same brick and mortar were used and full-scale wall was prepared and tested. Three double acting jacks were arranged as shown in **Figure 4.** and **Figure 5.** to apply cyclic loading and vertical loading, and in front of it load cell were attached to measure the load. Two LVDT were placed at top of steel frame to measure top displacement in steel frame as shown in **Figure 4. and Figure 5.**

Following Protocol were followed to apply the cyclic load on full-scale model of masonry wall. maximum of 20 mm displacement was applied and each displacement set has two cycle of loading. As shown in **Figure 6.**

3. TEST RESULT AND DISCUSSION

It is obvious that as strength of brick and mortar increases the ultimate load bearing strength of prism will also enhance. However, it not only the controlling factor on brick mortar joint interface. 1. Characteristic of bond between mortar and brick 2. Characteristic brick and mortar. 3. And overall quality of joint. 4. Slenderness ratio. Above said factor also influence the behavior and performance of masonry in lateral and axial loading.

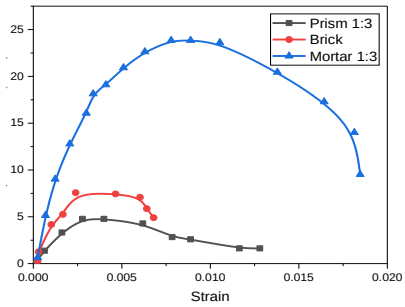

Figure 7. Comparison of Compressive Strength of Brick with 1:3 Prism and Mortar

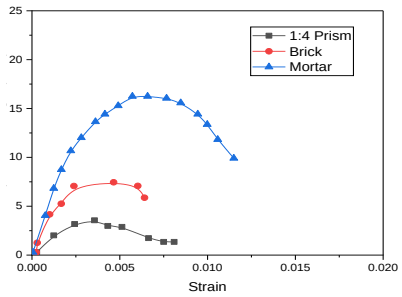

Figure 8. Comparison of Compressive Strength of Brick with 1:4 Prism and Mortar

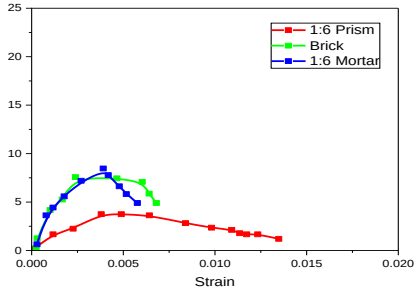

Figure 9. Comparison of Compressive Strength of Brick with 1:6 Prism and Mortar

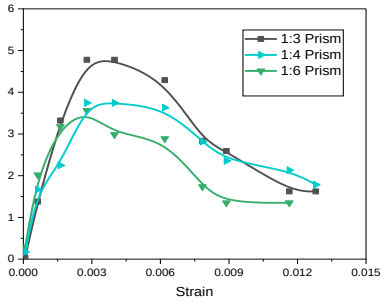

Figure 10. Comparison of 1:3,1:4,1:5 Mortar Prism.

4. NUMERICAL MODELLING

1.Micro modelling, in which the thickness of the mortar and the brick/unit are both taken into account and an analysis is performed. Because it is more precise, but it is also more complex to model and time-consuming. 2.Simplified micro modelling approach: Because this modelling is simple, micro modelling and mortar thickness are not visualized because a unit thickness contact exists between units/bricks and mortar. because it takes less time and produces satisfactory results.3. Macro modelling is considered homogeneous throughout the wall, and it is the quickest technique to analyses the wall, but the results are not as reliable as observed.[10]

To validate the FEM model experimental findings, the compression behavior of the tested masonry prisms and full-scale masonry wall was numerically analyzed, by simplified micro modelling approach as discussed in this section. The masonry prisms full scale masonry wall was then modeled using a Simplified micro-modeling technique. In the micro modeling technique, the block and mortar were each independently simulated, and a surface-based contact interaction was used between them, to simulate the interface behavior. The ABAQUS finite element tool [5] was used to accomplish the numerical modeling. Other concrete masonry research initiatives [6-9] have employed a similar numerical modeling approach in the past. The bricks and mortar layers were produced from eight nodded brick elements (C3D8R).

To model the interaction of masonry bricks and mortar, An Abaqus library constitutive rule accounting for the traction-separation of the interface was utilized. The initial linear elastic behavior of the interface is addressed in this model, followed by the continuation of interface degradation. As the compressive load is increased gradually and applied till the maximum stress develop in model of masonry prism and cyclic load on full scale model of steel frame infilled with brick masonry.

Concrete damage plasticity material model was used in modeling and following parameter were taken as shown in table 1. Material Properties of Brick properties are determined experimentally. Density of brick δ and Poisson ratio μ for brick is 1800 kg/m^3 and 0.15 respectively whereas E = 3.95x10^9 N/m^2.and for Steel E= 210 x10^9 N/m^2 and μ = 0.3.

Table 1. Concrete Damage Plasticity model properties.

Dilation Angle	11
Eccentricity	0.2
F_{bo}/F_{co}	1.17
Viscosity	0.003

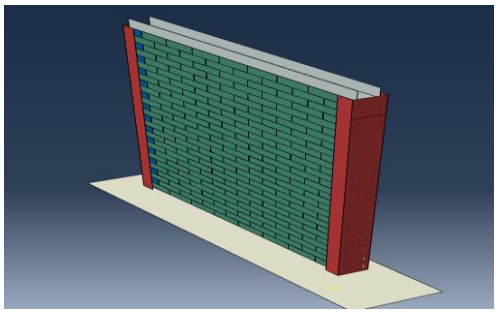

Figure 11. 3D Abaqus Model.

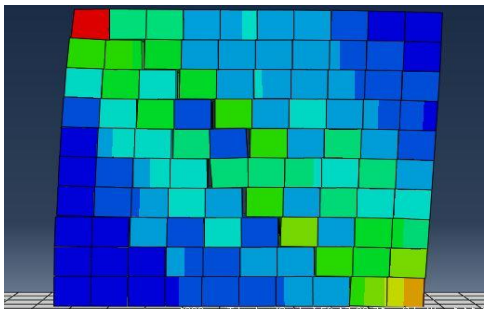

Figure 12. Crack Develop in First Cycle

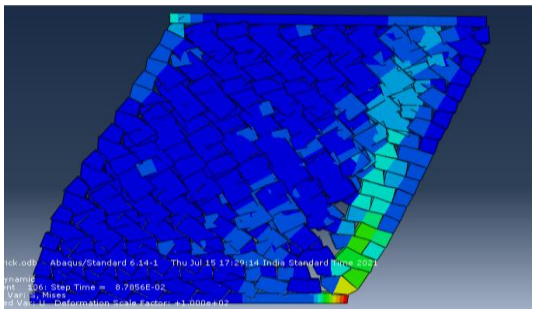

Figure 13. Final Over Toping and Crushing of Toe and Diagonal Crack in Last Cycle.

Figure 14. Experimental Crack Pattern After Cyclic Loading.

5. CONCLUSION

From above experimental and numerical modelling it is observed that there many factors that affect the masonry wall behavior during lateral loading. Such as 1. if strong brick and weak mortar is there crack propagate through mortar joint and debonding of brick take place. 2. If mortar is strong brick is weak brick get confined between the mortar and absorb more energy as compare to first case, and crack patter is not clear and toe or hill crushing of masonry take place 3. If both brick and mortar are strong then crack propagate through brick and mortar both. As observed when cyclic or lateral loading is applied on wall diagonal shear crack are observed in wall and masonry losses its strength in each cyclic load gradually.

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