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Simulation of Masonry Wall using Concrete Damage Plasticity Model

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Abstract- The objective of this article is to study the use of FE (Finite Element) tool in analyzed the masonry wall. Masonry is made up of highly nonlinear material and its property varies from place to place. It is difficult to do an experiment on a full-scale model of a masonry wall. Its effect is also underestimated in construction of low rise building. As if the wall is confined and properly bonded to the beam and column. It enhances the performance of low rise building during seismic forces. As in low rise building energy is dissipated by cracking. If masonry wall is cast monolithically (like confined masonry) with the column, it augments the stiffness of building and helps to sustain additional load compare to conventional construction practice. In this study numerical nonlinear analysis of wall panel is done by FE tool (ABAQUS). Using Concrete Damage Plasticity Model (CDP). And results are compared with the existing work done by other researchers and it is observed that results were satisfactory.

Keywords – Finite Element (FE), Concrete Damage Plasticity (CDP), Masonry wall.

I. INTRODUCTION

It was observed that from many decades masonry wall was considered as an only partition wall and it is not considered as a structural member in RCC frame structure. But in recent studies it was found that up to a few stories, we can use confined masonry wall. Up to three storey (floor to floor height 10 feet) building. It is observed by researchers that confined masonry is economical and effective then RCC frame structure up to three stories. Seismic response of structures to strong earthquake frequently produces excessive and uncontrollable lateral displacement as well as serious damages to structural and non-structural elements [1]. Masonry is classified as heterogeneous anisotropic material and analysis, understanding and capture of the structural behaviour of masonry are therefore complex. [2].

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II. FEM MODELLING

2.1 Type of modelling

There is three types of modelling of masonry done is done FE tool. They are 1. Micro modelling in which thickness of mortar and brick/unit both are considered and analysis is carried out. As it is more accurate but difficult to model and time-consuming.

2. Simplified micro modelling approach in this modelling is simple then micro modelling and thickness of mortar are not visualised as unit thickness interface is provided between units/bricks. 3. Macro modelling in this whole wall is considered as homogeneous and it is the fastest way to analyses the wall but results and not accurate as observed.

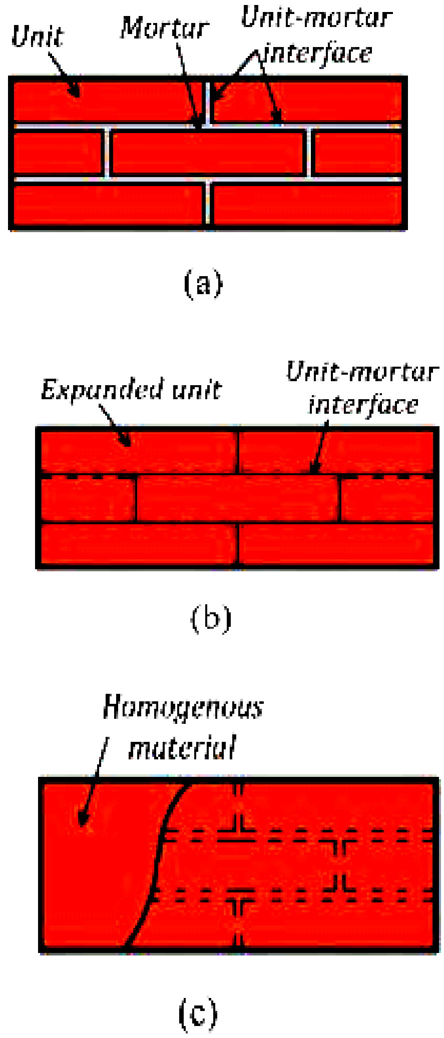

Figure 1. FE Modelling Approaches (a) Micro Modelling (b) Simplified Micro Modelling. (c) Macro Modelling [1]

FE Modelling and Analysis

In present simplified micro modelling approach. 3D hexahedral shaped eight node brick element with hour glass control (C3D8R) is used in modelling.[2] The interface is defined as a surface-based cohesive interface. Contact between adjacent masonry is General explicit surface to surface based contact. Model is generated in Abaqus standard/explicit, mesh size is chosen based on mesh analysis study. Where mesh size is changed and results are compared and we found that current provided mesh size gives an optimum solution with less time consumption. i.e. 6 x 2 x 3 element in a brick/unit. The dimension of the unit available in the locality was 195mm x 90mm x 70mm. So same dimension are been modelled. Thirteen courses high and 780 mm width single brick masonry wall is modelled.

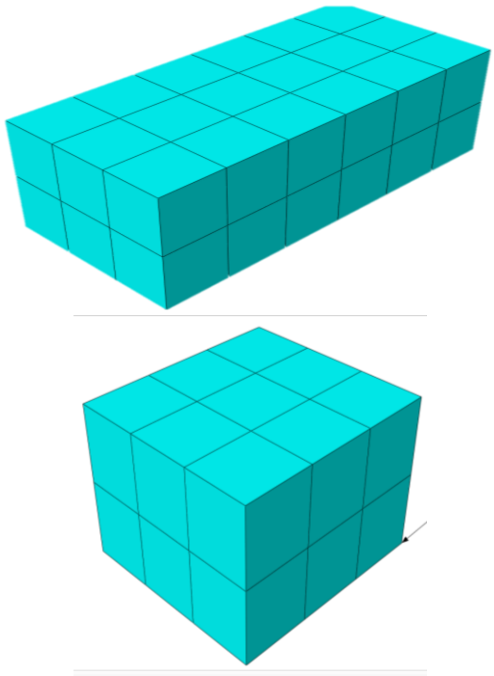

Figure 2. Brick/Unit Mesh Size with C3D8R element.

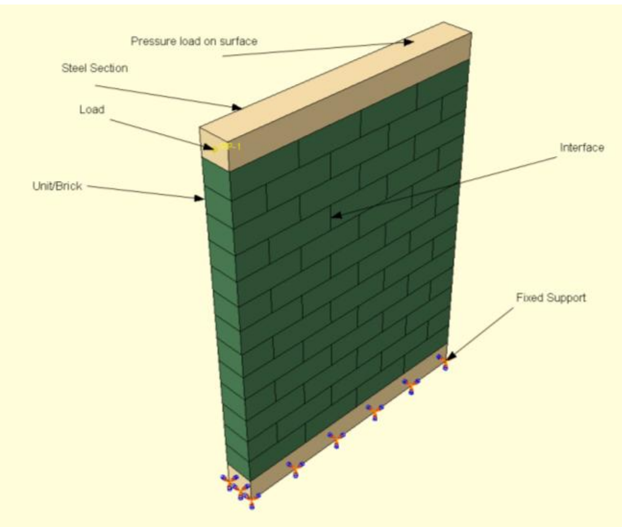

Figure 3. Model of Masonry in Abaqus with other details.

Figure 3 shows the material properties of masonry and steel separation in modelling and location of loads. Based is fixed and vertical pressure is applied in the initial step and lateral load is applied in the second stage where coupling contact is defined. At the centre of the steel section as shown in Fig. 3.

Material Properties

Brick/unit properties are determined experimentally. Density of brick δ and Poisson ratio μ for brick is 1900 kg/m^3 and 0.15 respectively whereas E = 3.98x10^9 N/m^2. Steel E= 210x10^9 N/m^2 and μ = 0.3. As provided by the manufactural.

Table 1. Concrete Damage Plasticity Material Property

Dilation Angle	10
Eccentricity	0.1
F_{bo}/F_{co}	1.16
Viscosity	0.002

Lateral load of 6600 N was applied on the steel section connected on the top of the masonry in the second step and an initial step a pressure force of 240000 N/m^2 was given. Dynamic Explicit Model was used in the step.

Table 2. Interface Property.

Tangential Behavior Frictional co efficient	0.7
Maximum Nominal Stress in Normal Direction	61100 N/m^2
Maximum Nominal Stress in Shear Direction -I	93350 N/m^2
Maximum Nominal Stress in Shear Direction -II	93350 N/m^2
Plastic Displacement	0.001 m
Exponential Parameter	10
Viscosity	0.002

III. SIMULATION RESULT AND VALIDATION

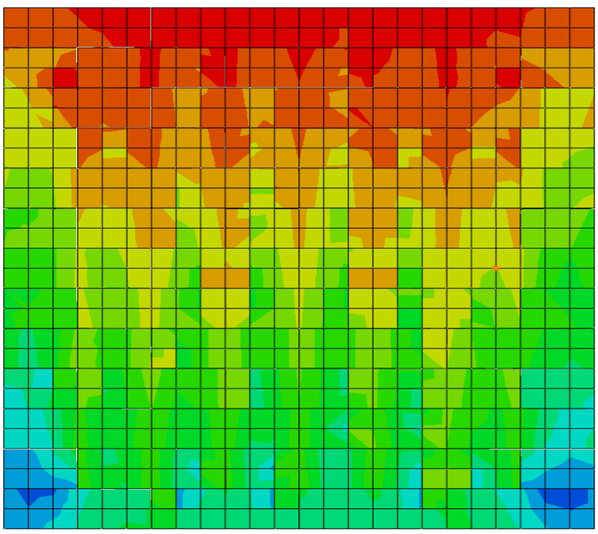

Figure 3. (a) shows the vertical stress in masonry during the initial step where only vertical pressure is applied and no failure was observed in the analysis of the model.

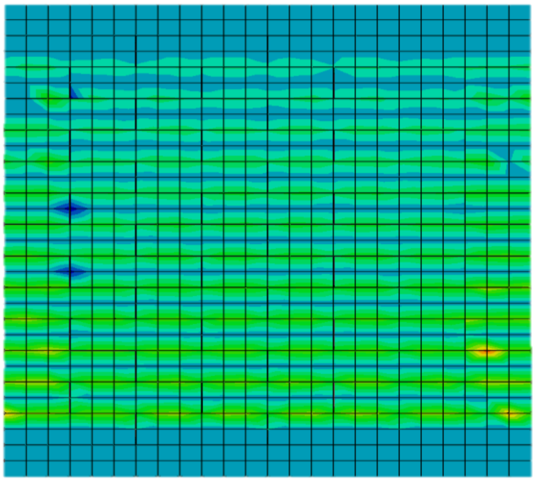

Figure 3. (b) shows the horizontal stress in masonry during the step where only horizontal pressure is applied and no failure was observed in the analysis of the model.

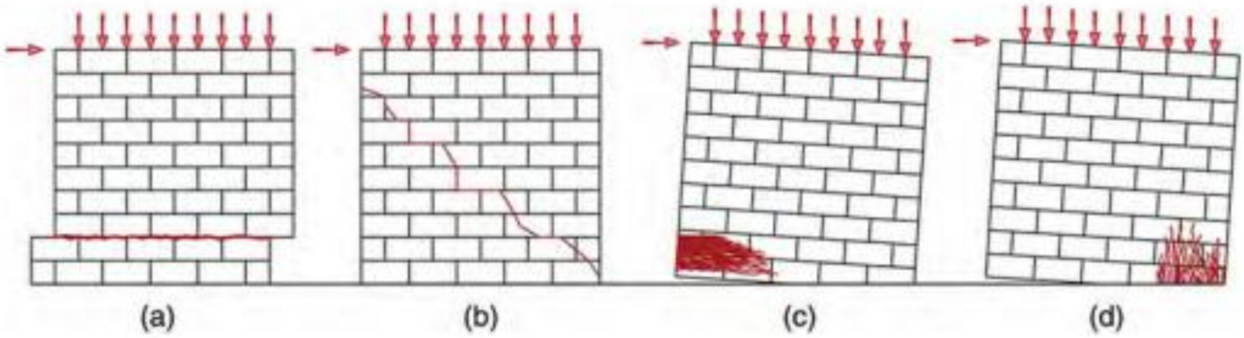

Figure 4. shows the rocking failure and toe-crushing ar per the researcher has found failure in masonry in seismic loading.[5]

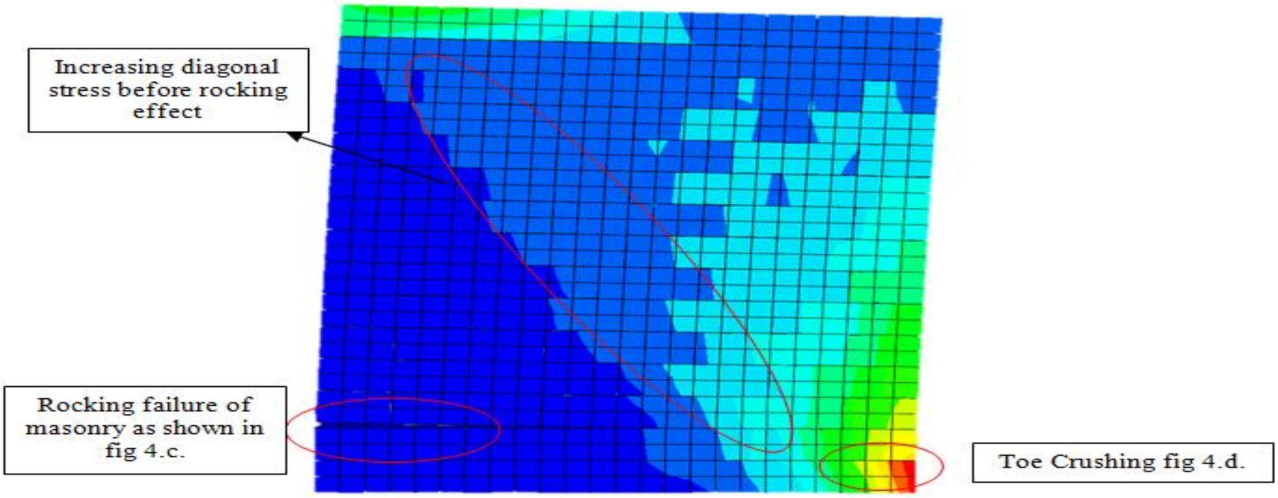

Figure 5. shows the rocking failure, toe-crushing and stress in FEM model analysis in abaqus.

Simulation results and failure pattern shown by the author are similar and validate the results by concrete damage plasticity model. This can be a new method and approach to analysing the masonry wall.

IV.CONCLUSION

Numerical analysis of masonry wall by simplified micro model approach is a better way to analyse masonry. And beneficial were to perform the experiment is not convenient. Rocking failure was dominant here in this study. If the bond between masonry and mortar is strong might be possible that diagonal crack will be a dominant failure in the same masonry.

It gives accurate results and has validated with the author. As masonry is highly nonlinear and varieties of masonry units are available CDP model has validated the brick masonry model. Might not be valid to stone masonry or block masonry.

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