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Study of Seismic Effect in Unreinforced Masonry Structures with Openings

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Abstract— From beginning of civil construction masonry structure has a leading role due to its easily availability, low cost, due to its fire resistant capacity, good sound and mainly due to the availability of skilled labours. The strength and durability of the masonry structure mainly depends on the quality of the materials, mortar and the labours. This type of buildings is very vulnerable during earthquake and sometimes the entire structure may collapsed. So in earthquake prone areas proper monitoring should be given for the masonry structures. Various studies are carried out in this field.

The main aim of this study is the effect of opening in the URM structures corresponding to the seismic action. For this study different length to breadth ratio (L=B, L=1.2B, L= 1.4B, L=1.6B, L=1.8B, L=2B) of 1150 sft uniaxially symmetric buildings plans are taken. Here in this plans opening area and the built-up area of all structures are same but the percentage of the opening will change according to the type of plan. These plans are modelled and analysed with the help of 3MURI software. Then the performance point of all the building is determined with the help of pushover cure obtained from the software and a comparative study of all buildings were carried out.

Index Terms— unreinforced masonry, effect of opening, eccentricity, wall density, pushover analysis, capacity and demand curve, performance point

1 INTRODUCTION

The seismic behaviour of masonry structures is very difficult to characterize depending on several factors like the material properties, the geometry of the structure, the connection between the structural and non-structural elements, the stiffness of the horizontal diaphragms and the building conditions. Masonry is a heterogeneous material consists of units and joints. Where the units are bricks, blocks, ashlars, adobes, irregular stones and others. The mortar can be clay, bitumen, chalk, lime/cement based mortar, glue etc. Masonry building systems composed of vertical and horizontal structural elements, walls, floors connected in every direction. The construction of masonry structures can be classified into:

- Unreinforced Masonry
- Reinforced masonry
- Confined Masonry

Unreinforced masonry structures(Fig.1) is mainly consists of load bearing walls, non-load bearing and other structures like chimneys are made up of bricks , underblocks, tiles ,adobe or other masonry materials are not braced by reinforcing material (like rebar in concrete or underblocks). These type of structures are vulnerable to collapse during earthquake. The major problem for this is the mortar used to hold bricks is not much strong.

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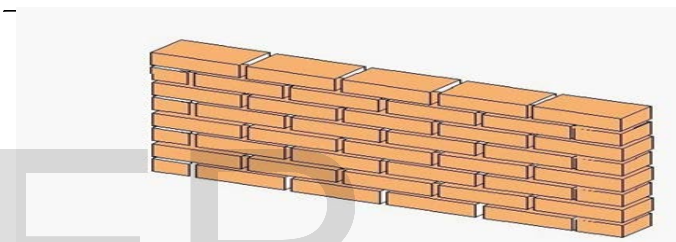

Fig. 1. Unreinforced masonry

In reinforced masonry (Fig. 2), the steel reinforcement is in the form of bars or mesh is embedded in the mortar or placed in the holes and then it is filled with concrete or grout. Which is capable of resisting both compressive and tensile shear stress. For this the reinforcement should be integrated with masonry then only all materials of the reinforced masonry system act monolithically when resisting gravity and seismic loading. Because of its ability to resist the lateral forces it is used in seismic prone areas.

Fig. 2. Reinforced masonry

In confined masonry (Fig. 3), the structural walls are confined on all four sides with reinforced concrete or reinforced masonry vertical and horizontal confining elements.Confined masonry is not carry the vertical or the horizontal loads, and which is not designed to perform as a moment- resisting frames; however they are intended to carry all vertical and seismic loads.

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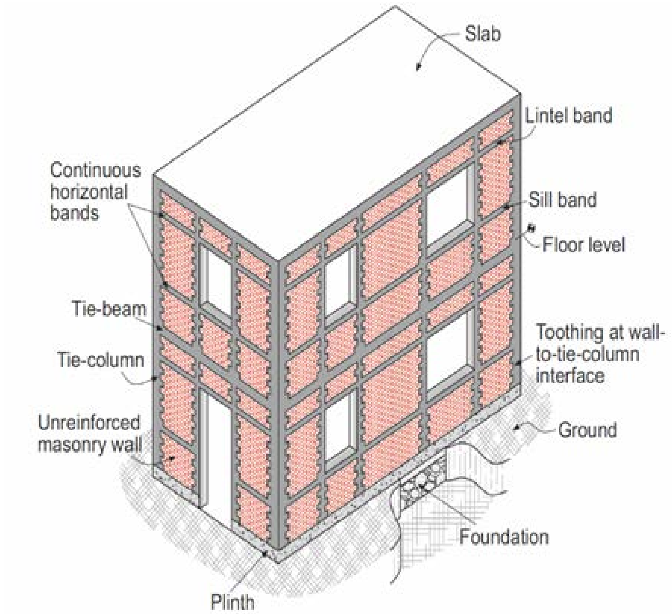

Fig. 3 Confined masonry

There are different methods of seismic analysis having different degree of accuracy. It is generally categorized on the basis of three factors namely ,type of external applied loads , behaviour of structure or structural materials and the selected type of structural model. Based on the type of external action and the behaviour of the structure, the analysis classified as linear static and dynamic analysis. These are the following typical damage pattern observed after earthquake:

- Cracks between walls and floor
- Cracks at the corners and at wall intersection
- Out -of plane collapse of perimetral walls
- Cracks in spandrel beam or parapets
- Diagonal cracks in structural walls
- Partial or complete collapse of the building
- Partial disintegration or collapse of structural walls

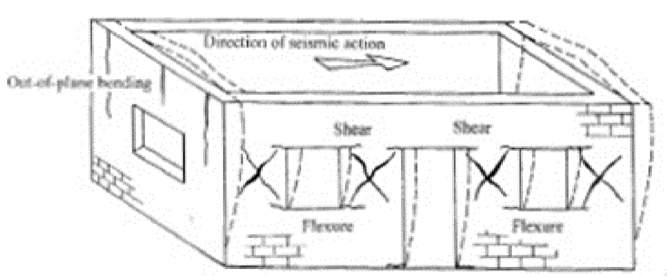

Fig. 4 Deformation of the building and typical damage to the structural wall [2]

2 METHODOLOGY

After a brief description of the adopted models (L=B, L=1.2B, L=1.4B, L=1.6B, L=1.8B, L=2B) and analytical validation, this paper focus on the effect of openings influences the strength of uniaxially symmetrical URM structures during an earthquake. Different types of analysis methods are there for the study of effect of masonry structures after earthquake. Finite element modelling analysis is a most suitable method to analyse a masonry structure because it give more finite and accurate result. Inelastic strength and deformation demands can be determined by using nonlinear static analysis or push over analysis. Here 3 dimensional modelling and analysis of the structure is going to do by using the 3MURI software. The displacement and shear of the building will get from the pushover curve this helps to find the performance point of the building. It will help to compare the performance of all models and can identify which building has more performance against earthquake.

The equivalent frame method (Fig. 5), is used for the structural element modelling. Here both the walls and lintel beams are treated as discrete frame members, focusing on the in-plane response of complex masonry walls with openings. Piers and spandrels are the two structural components. Piers are the main vertical resistant elements carrying both vertical and lateral loads. Walls and beams are linked to each other by means of rigid arms in order to take into account the actual finite width of the wall. In fact, the application of conventional frame discretization yields inaccurate results when dealing with shear wall systems .However, these results can be improved through the definition of a set of special devices to represent more realistically the shear deformation of the wall.

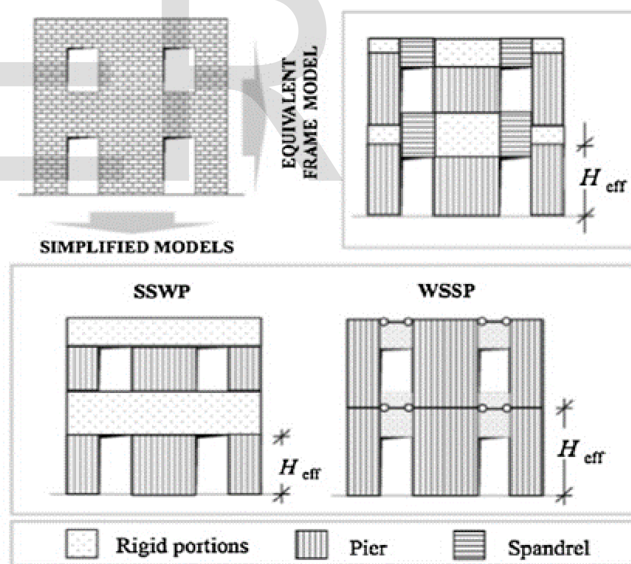

Fig. 5 URM wall idealization according to simplified and equivalent frame models. [8]

2.1 Study

The building considered for the numerical analysis is a uniaxially symmetric building plan .It is a one storey building with a total height of 3m.in fig. 6 shows the L=B plan view. According to this modify the plans to L=1.2B, L=1.4B, L=1.6B, L=1.8B, L=2B are modelled and analysed by using 3Muri software. The wall thickness of the building is 24 cm.

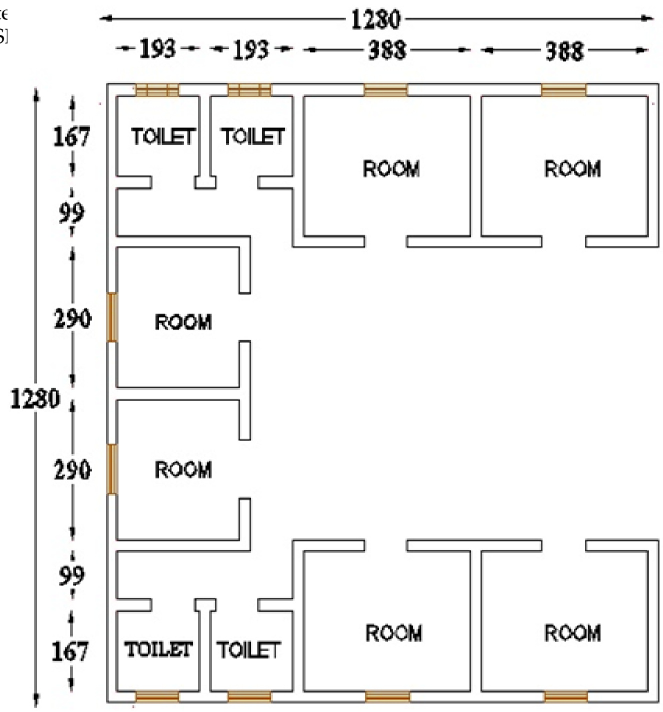

Fig. 6 Building plan 1

The center of mass and center of rigidity of all plans are calculated. These are depends on the storey height, shape of the structure and the openings. From the difference of center of mass and center of rigidity will give the eccentricity of the building. The rigidity of walls in X and Y direction and the center of gravity of corresponding walls will give the eccentricity in that particular direction.

The material properties of all plans are same and that are given below:

TABLE 1
BUILDING PARAMETERS

Symbol	Definition	Values
E	Young's modulus	1800N/mm2
G	Shear Modulus	250 N/mm2
W	Load Weight	19kN/m3
Fm	Mean Compressive Strength	2.96 N/mm2
fvmo	Mean Shear Strength	0.25N/mm2
fvlim	Shear strength limit	0.11
fk	Characteristic Value	2.46
Gk	Dead Load	1 kN/m2

2.2 Modeling and analysis of URM structures using 3muri

3MURI is an analytical software developed for the structural and seismic analysis of masonry building. It is mainly based on the equivalent frame modelling approach incorporating several macro-element models for the simulation of masonry and non-masonry structural members. The macro-element analysis contain piers, spandrel strips. It will give all possible failure mechanisms like composed flexural and axial load, tensile shear and sliding shear. The reduction of the section (induced by cracking) helps to evaluate the stiffness degradation which involves the panels stress variation generated by external actions. Both nonlinear static and dynamic analyses of a 3D building can be done by using this software and this also provide a clear understanding result.

By using the parameters given in table 1 the above plan is modelled in 3MURI software. The meshes are generated automatically and after completing the analysis we will get a pushover curve in terms of shear and displacement. It is a plot of base shear vs lateral displacement.

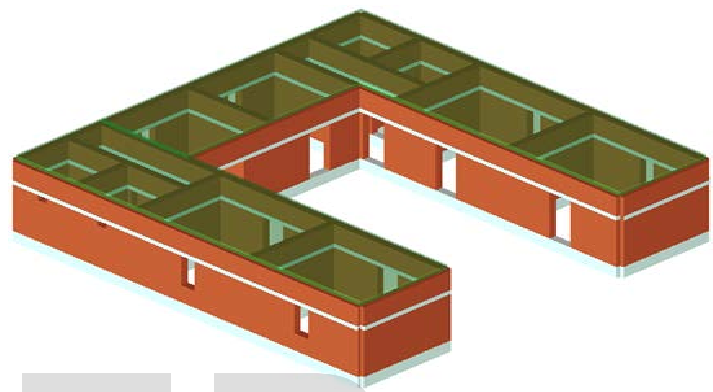

Fig. 7 3D model of plan 1

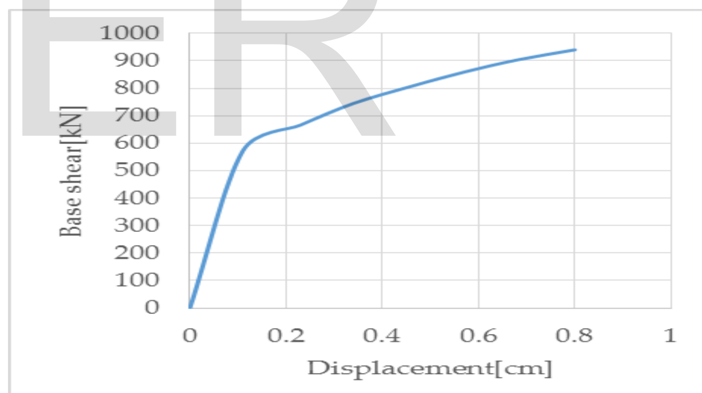

Fig. 8 Pushover Curves in X direction

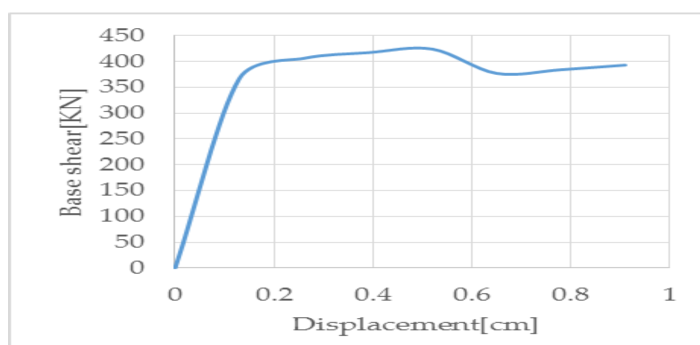

Fig. 9 Pushover Curves in Y direction

2.3 Performance Point

It is a point where capacity curve and demand curve coincides. Both of these curves are mutually dependent. In the case of a capacity spectrum, where displacement increases the period of the structure lengthens. At the performance point both the capacity and demand are equal. So there is a need of covert them in to a common scale ie. Spectral acceleration vs. spectral displacement. This format of plotting is known as Acceleration – Displacement Response Spectra (ADRS). Each point on a response spectrum curve has associated with unique spectral acceleration, Sa, spectral velocity Sv, spectral displacement Sd and period T. To convert from Sa vs.T found in building codes to ADRS format, it is necessary to determine the value of Sdi for each point on the curve. Fig. 10 shows the performance point.

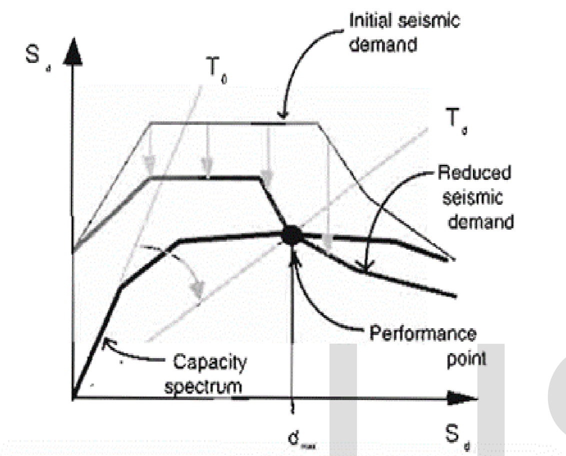

Fig.10 capacity vs. demand curve [1]

3 RESULT AND DISSCUSION

1. The eccentricity of the building depends on the geometry of the structure. The center of mass, center of rigidity and eccentricity of the building shown below:

TABLE 2
COM, COR, ECCENTRICITY AND % OF OPENING OF DIFFERENT PLANS

Building	Eccentricity		% of opening		Wall density	
	X	Y	X	Y	X	Y
L=B	0.43	0.02	10.31	3.79	11.17	8.56
L=1.2B	0.42	0.03	11.23	3.5	10.16	9.11
L=1.4B	0.39	0.04	11.96	3.29	9.38	9.99
L=1.6B	0.36	0.05	12.22	3.15	9.33	10.46
L=1.8B	0.35	0.06	12.82	2.93	8.23	11.24
L=2B	0.34	0.07	14.06	2.84	7.63	11.66

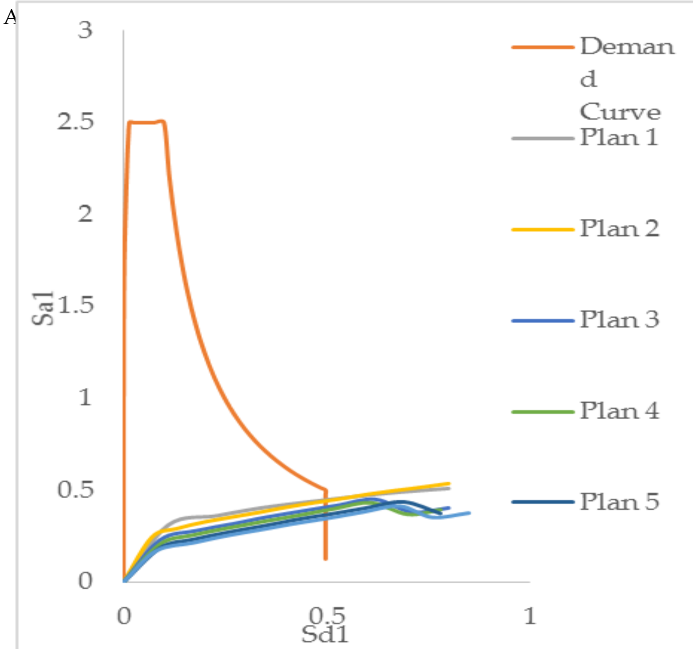

Fig. 11 capacity vs. demand curve in X direction

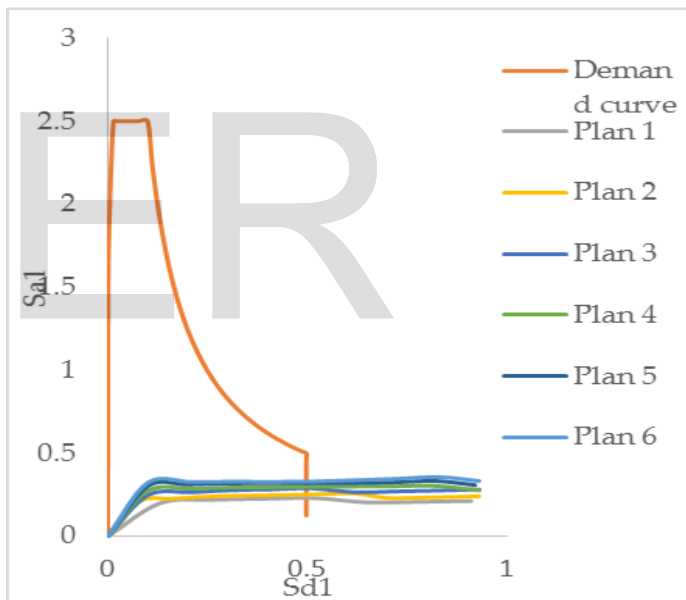

Fig. 12 capacity vs. demand curve in Y direction

2. The performance point of X and Y direction is plotted for all 6 plans having different eccentricity. From X direction graph it shows that the building 1 has more efficiency because the ey of building 1 is 0.02 while the building 6 has comparatively less efficiency, its ey is 0.07.

3. From Y direction graph it shows that the building 6 has more efficiency because the ex of building 6 is 0.34 while the building 1 has comparatively less efficiency, its ex is 0.43.

4. The opening percentage is another parameter, here the efficiency of the building increases for decrease in opening percentage. . The opening percentage of building 1 in X direction is 10.314 this is smaller than the other building,

so it has higher performance than other building .The plan 6 has comparatively small efficiency because its opening percentage is 14.06.But in Y direction graph opening percentage of building 6 is 2.836 this is smaller than the other buildings, so it has higher performance than other building .The plan 1 has comparatively smaller efficiency because its opening percentage is 3.789

5. Wall density effect the performance of the building very much by increasing wall density the performance of the building increases from the above study building 1 has higher wall density ie 11.17 in x direction but in y direction building 6 has higher performance its wall density is 11.66.

4 Conclusion

This work include the seismic analysis of six type building having same built-up area, same opening size and different length breadth ratio and different eccentricity. The conclusion obtained from this study are listed below:

- The eccentricity influence the strength of the building .The eccentricity increases the efficiency of the building decreases.
- Openings are another parameter in this study, here the opening percentage decreases the efficiency of the building increases.
- Wall density effect the building very much by increasing the wall density the performance of the building also increases.

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