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Seismic Analysis of Interlocking Block as Infill Wall

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Abstract - *In this study, an attempt is made to analyze the structure when the infill wall is modeled using interlocking blocks. In this study building frame, wall, foundation, soil is modeled using ANSYS CIVIL FEM software. In analyzing the building different conditions considered are (a) Single storey with single bay frame without considering the interlocking infill on Gravel well graded soil with earthquake load along x direction; (b) Single bay frame with interlocking infill walls built along x direction; (c) Single bay frame with brick infill walls built along x direction; (d) Single storey with single bay frame without considering the interlocking infill with earthquake load along z direction;(e) Single storey single bay frame with interlocking infill walls built along z direction; (f)) Single storey single bay frame with brick infill walls built along z direction on gravel well graded soil. The static non linear analysis is used to analyze the model. The displacement and stress results obtained along different co - ordinates are studied and compared. Comparison of results obtained is done between interlocking infill wall, brick infill walls and single storey single bay frame without any infill.*

***Key Words*: INTERLOCKING BLOCKS, INFILL WALL, STATIC NON LINEAR ANALYSIS, DISPLACEMENT, STRESS**

1. INTRODUCTION

In most of the developing countries with the increase in population the housing facility is inadequate. Due to high rate of urbanization the cost of land and materials of construction are increasing rapidly. Hence the poor class of society cannot afford for proper housing. The new structural component desired to be developed in masonry buildings construction is new interlocking mortar concrete masonry blocks. Based on previous studies it was found that because of the use of interlocking blocks the cost and time required for construction gets reduced. Mortar less load bearing wall built using interlocking block is dissimilar from usual mortared brickwork systems in which there is no mortar layer and instead of that each block are connected to each other by groves and protrusion. Interlocking blocks produced from compressed stabilized soil will have good fire resistant and insulation properties [1]. When the climate condition is dry, wall constructed using stabilized soil gave good compressive strength. Expansion of interlocking earth block is one of the best technologies for the production of low cost building material. In load bearing system of the building wall will also act considerably in resisting the lateral loads acting on building. Hence walling material is very essential in construction. It was found that it constitute about 22% total cost of the building. Hence it is necessary to find the material which is cost effective. Interlocking stabilized earth blocks have satisfactorily reduced the cost of construction by reducing the mortar joints. If the interlocking blocks are well stabilized they will serve the aesthetic property also. Different types of interlocking blocks are being developed worldwide. The aim of this project is to check how effectively a wall built using interlocking block will resist the lateral loading like earthquake load. Interlocking blocks are developed with various shapes, dimension and also with various interlocking mechanism. Few of the interlocking block types and their mechanism are mentioned below

1.1 Interlocking Masonary Wall System

Interlocking system of building walls is either dry stacked or minimum amount of mortar is used between blocks. Dry stacked means building without using mortar, but minimum amount of mortar is used for bottom and top two layers of block. Building wall using interlocking blocks is easier because well skilled labor is not required; not only has that it reduced the use of mortar. Since the cost of interlocking block is comparatively less than other sources; since wall surfaces built using this block is even there is no need of plastering; blocks can be produced in site thus it reduces overall construction cost. Steel reinforcement can be provided within the interlocking layers. Out of different types of blocks hydra form blocks are used for this study. The main feature of interlocking brick is self alignment. They must be fitted into each other without shaving, cutting, shimming. They must be properly oriented. In most of bricks interlocking is by protrusion and depression, but few are due to topological non planar contact.

2. METHODOLOGY

In the present study, ANSYS Civil FEM Software is used for Seismic Analysis of structure. Interlocking block is modeled using SOLID 95 element. By using TARG 170 and CONTA174 elements contact is developed between each layer of interlocking blocks. Dimension of building is 6m × 4m. Each floor height is 3.5m. Soil layer f 3m depth is also considered in this study. Material used for analysis is Fe 415 steel and M25 grade of concrete. Thickness of slab is 150mm.

Table -1: Description of components of model

Dimension of column	
Width	0.23m
Depth	0.45m
Dimension of beam	
Width	0.23m
Depth	0.45m
Dimension of Footing	
Length	1.5m
Breadth	1m
Depth	0.5m

Table -2: Salient Observations Of IS- 1893 (Part 2) 2002

Seismic Zone	Zone II
Soil Type	Type II (Medium soil)
Importance factor(I)	1.0 (IS: 1893- 2002) part II Table- 6, cal, 6.4.2, pp.18
Response Reduction Factor (R)	3.0 (OMRF) (IS: 1893-2002) part II Table- 7
Damping	5%
Spectrum Type Of Analysis	Design Basis Earthquake

After defining all the parameters of analysis, apply self weight and also live load of 3kN/m^2 to the structure. Then non linear static analysis is conducted. After static analysis define all the parameters as mentioned in table 2 and seismic analysis is done.

In this study, six different models are created as mentioned below:

1. Model 1: Here only frame model is considered for study and load is applied on all beams.
The brick load calculated is applied on plinth beam.
Earthquake load is applied in x direction.
2. Model 2: In this case wall using interlocking block is modeled only along longer length of building and earthquake load is applied along x direction.
3. Model 3: In this wall is modeled using brick along x direction and earthquake load is applied along x direction.
4. Model 4: Here only frame model is considered for study and load is applied on all beams. Earthquake load is applied in z direction.
5. Model 5: In this case wall is modeled using interlocking block along z direction of building and earthquake load is applied in z direction i.e. direction of wall built.
6. Model 6: In this case Wall is modeled using brick along shorter length of building i.e. z direction and earthquake load is applied in the same direction.

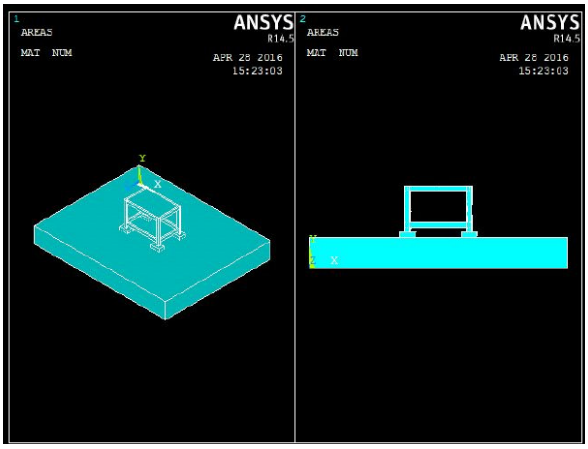

Fig-1: Isometric and front view of model 1 and model 4

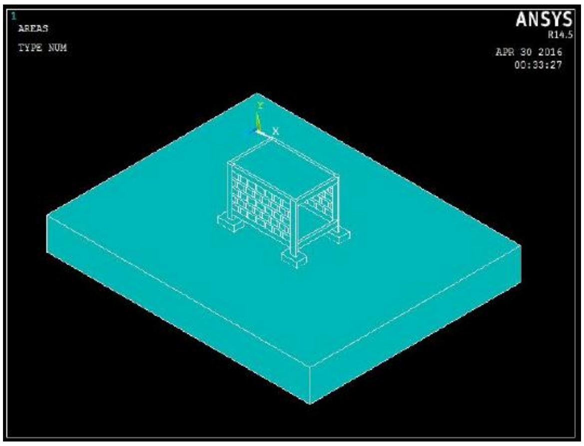

Fig -2: Isometric view of model 2

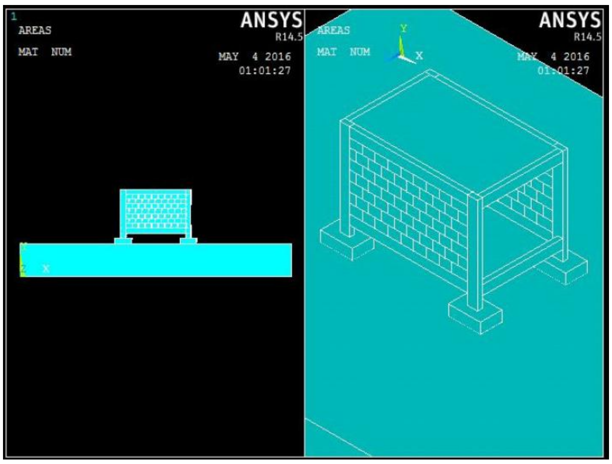

Fig -3: Isometric view of model 3

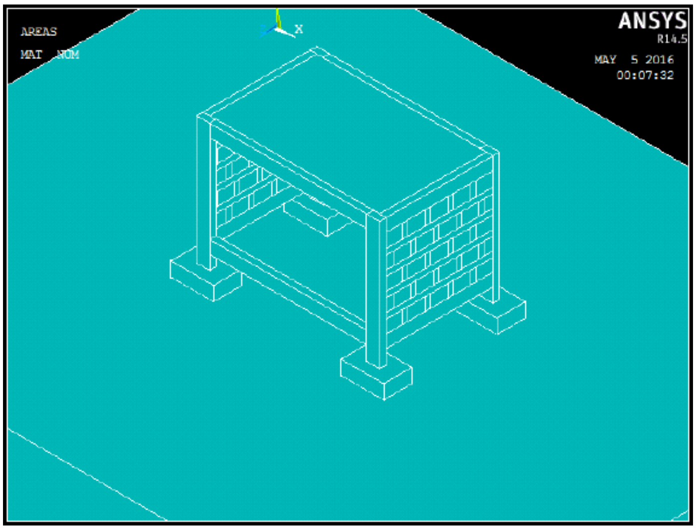

Fig -4: Isometric view of model 5

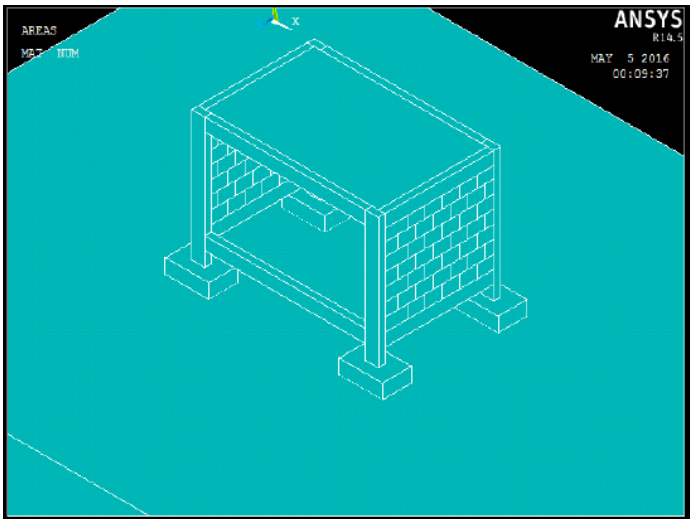

Fig -5: Isometric view of model 6

3. RESULTS AND DISCUSSION

. Seismic analysis is also done for different models and compared with each other. The results obtained are displacement and stresses in all the directions.

3.1 Comparison of Displacement Results for Different Models

3.1.1 MODEL -1

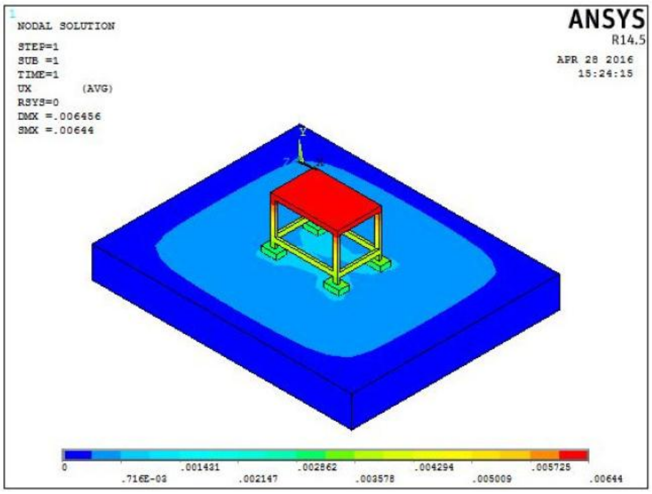

Fig -6: Displacement Along x Direction

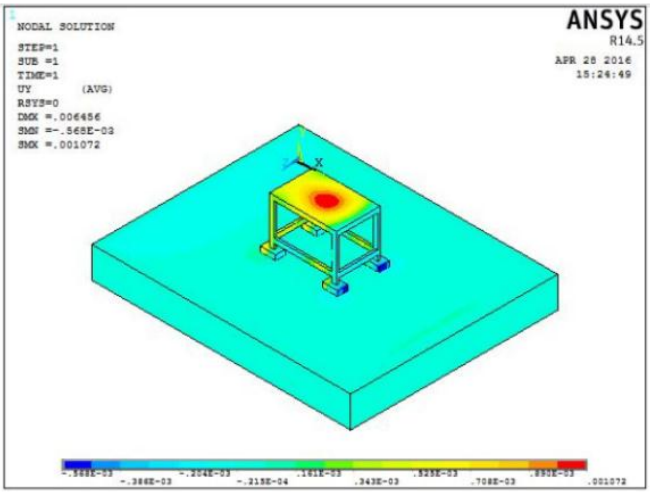

Fig -7: Displacement along y Direction

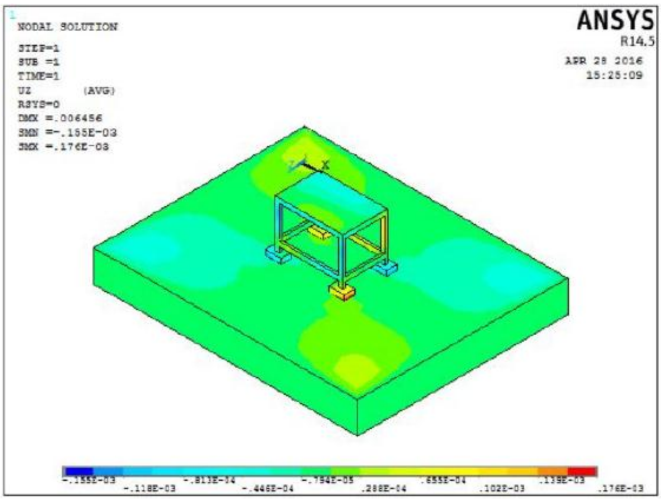

Fig -8: Displacement Along z Direction

3.1.2 MODEL -2

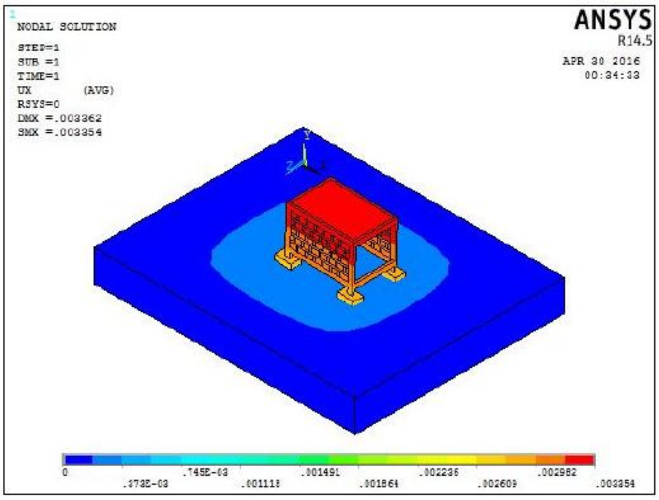

Fig -9: Displacement Along x Direction

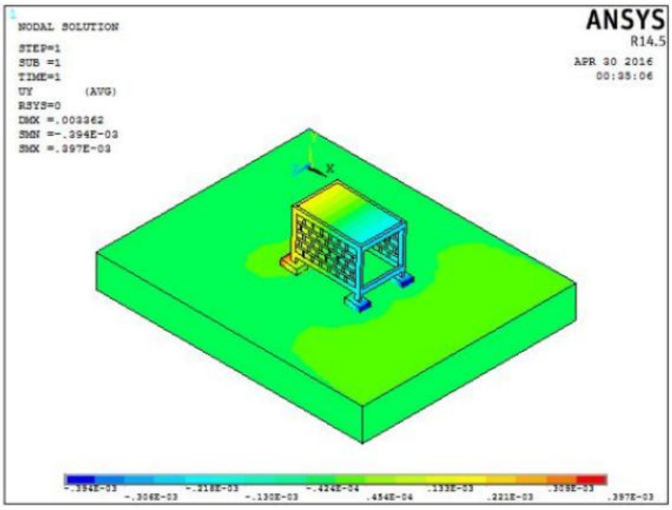

Fig -10: Displacement along y Direction

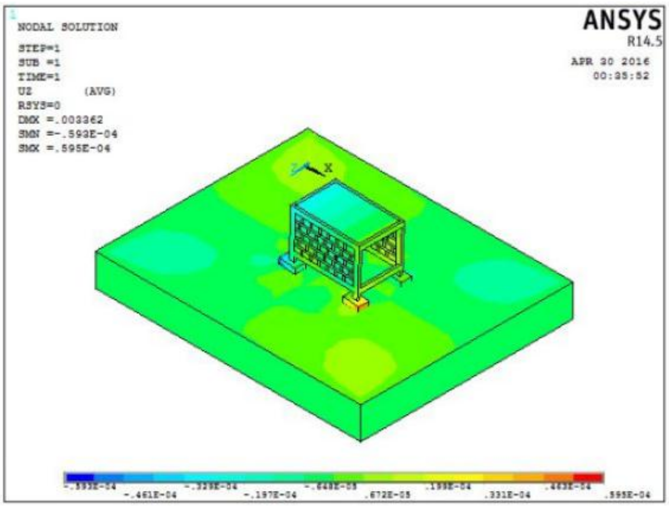

Fig -11: Displacement Along z Direction

3.1.2 MODEL – 3

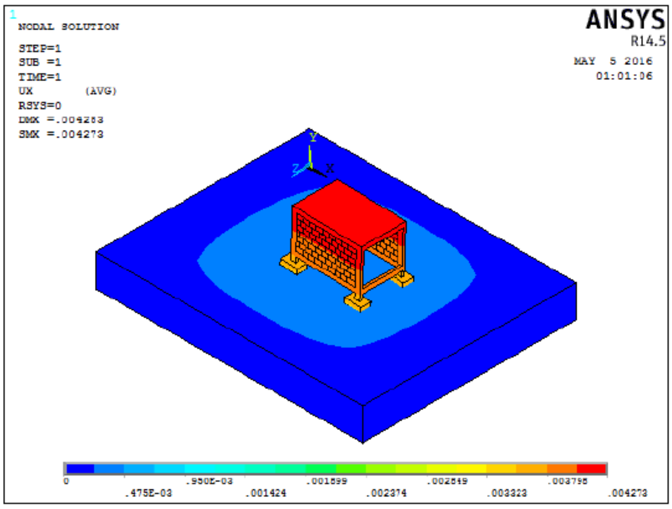

Fig -12: Displacement Along x Direction

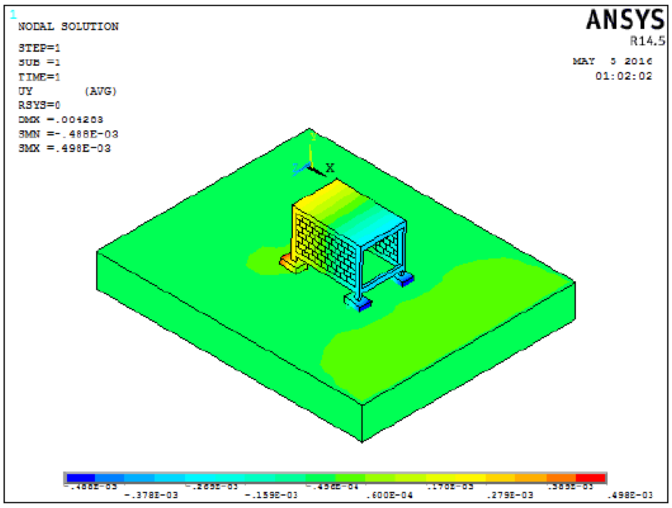

Fig -13: Displacement along y Direction

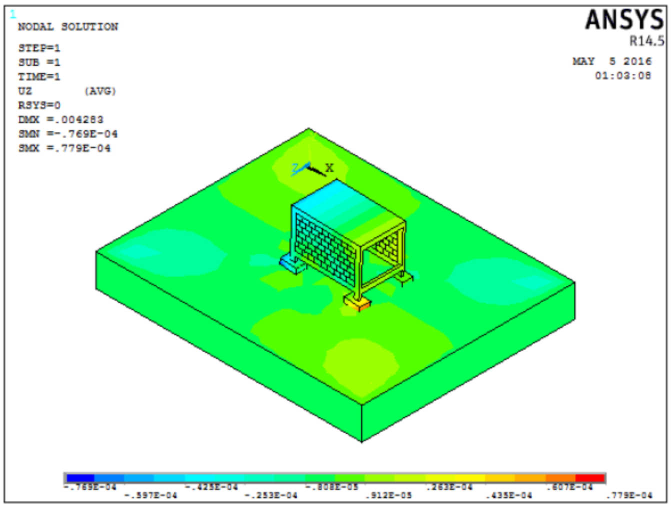

Fig -14: Displacement Along z Direction

Table no 3: Comparison of displacement results of model 1, 2 and 3

Model no	x direction displacement values (mm)	y direction displacement values (mm)	z direction displacement values (mm)
1	6.44	1.072	0.17
2	3.362	0.394	0.0595
3	4.273	0.49	0.0779

Similarly the displacement values of remaining models are compared each other as mentioned in the table below.

Table no 4: Comparison of displacement results of model 4, 5 and 6

Model no	x direction displacement values (mm)	y direction displacement values (mm)	z direction displacement values (mm)
4	0.149	1.113	9.09
5	0.0527	0.835	5.487
6	0.081	0.93	5.65

3.2 Comparison of Stress Results for Different Models

The stress developed due to application of seismic loads on the structure is compared and results are tabulated as shown in table 5 and 6.

3.2.1 MODEL 1

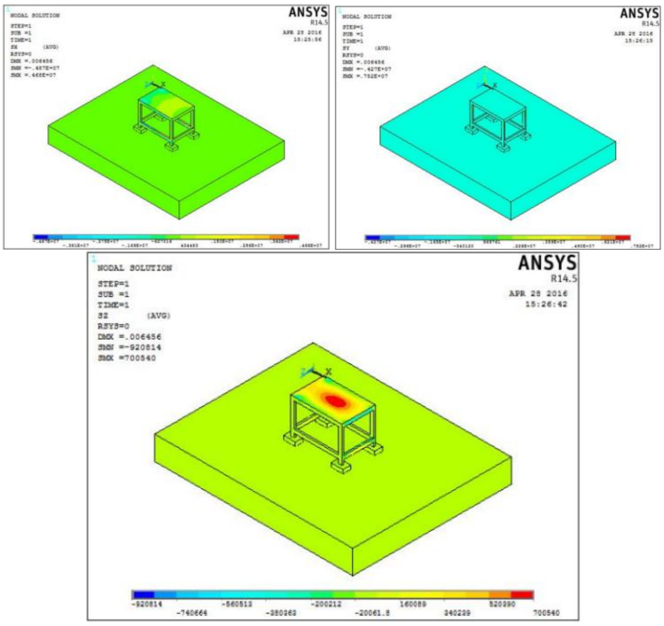

Fig -15: Stress Along x, y and z Direction

3.2.2 MODEL 2

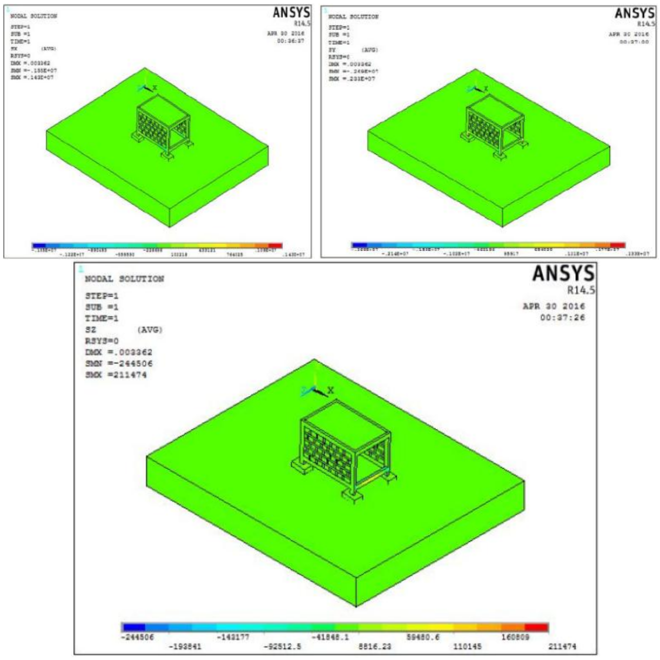

Fig -16: Stress Along x, y and z Direction

3.2.2 MODEL 3

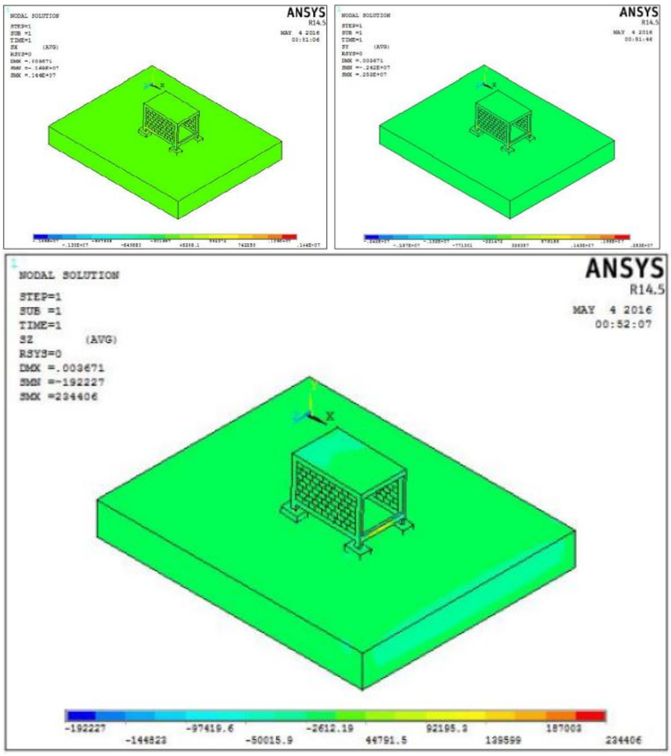

Fig -17: Stress Along x, y and z Direction

Table no 5: Comparison of stress results of model 1, 2 and 3

Model no	x direction stress value (N/m^2)	y direction stress value (N/m^2)	z direction stress value (N/m^2)
1	4.68×10^6	7.52×10^6	7.005×10^6
2	1.43×10^6	2.33×10^6	2.11×10^6
3	1.69×10^6	2.56×10^6	2.34×10^6

Similarly the stress values of remaining models are compared each other as mentioned in the table below.

Table no 5: Comparison of stress results of model 4, 5 and 6

Model no	x direction stress value (N/m^2)	y direction stress value (N/m^2)	z direction stress value (N/m^2)
4	1.61×10^6	8.34×10^6	8.71×10^6
5	5.84×10^6	6.02×10^6	4.93×10^6
6	6.21×10^6	6.215×10^6	5.21×10^6

4. CONCLUSIONS

The seismic analysis of single storey single bay frame with infill wall built using interlocking block and brick are conducted and compared. In order to obtain more realistic value for stress and displacement results, we have conducted 3D analysis of structure. When compared the displacement result of the frame with interlocking block wall, brick wall and frame without any infill wall (bare frame) it has been observed that:

- Structure with infill wall built using interlocking block has lowest value of displacement when compared with other two models.
- It has been observed that overall displacement of interlocking block wall is reduced by about 47% when compared with frame without infill wall and about 21.4% when compared with brick infill wall. In these cases earthquake load is applied in the direction of wall. When compared the stress results of frame with interlocking block wall, brick wall and frame without any infill wall, it has been observed that:
- Structure with infill wall built using interlocking block has lowest value of stress when compared with other two models.
- It has been observed that overall displacement of interlocking block wall is reduced by about 69% when compared with frame without infill wall and about 15% when compared with brick infill wall.
- In all the cases stress value is more in y direction.

Thus interlocking block will be effective in resisting the earthquake loads. Based on the literature survey cost of interlocking block is less than brick. Hence interlocking block is the best component in masonry construction.

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