THE INTERNATIONAL JOURNAL OF
SCIENCE & TECHNOLEDGE

Study of High Rise Structure with Soft Storey at Different Level by Considering Slab as Shell and Membrane

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Abstract:
The effect of Infill's are often neglected because of the hurry in construction of the skeleton members. Even though the analytical and experimental studies on response of infilled frame have taken place from 1950, they have less considered the involvement of infill in the structural behaviour. The collapse mechanism is being changed if the involvement of infill's walls is considered, and providing soft storey at different level changes the behaviour of building. The consideration of slab as a membrane and slab as thin shell is also taken into account and what effect it has to the behaviour of building is discussed. Dynamic analysis of a 25 storey L shaped building is carried out. Behaviour of slab as membrane and thin shell is evaluated by response spectrum method.

Keywords: *Infill walls, lateral load, thin shell, membrane, response spectrum*

1. Introduction

The study of the influence of infill walls was carried out during the past recent years. Serious damages can occur to a structure if the infill walls are not considered in the analysis. We commonly see the use of these infill walls in various structures. They are been used for commercial and residential buildings. Also, they are being used for the separation of the building from the outside environment. Infill wall do not take up any load, i.e. they are non-load bearing.

1.1. Effect of Infill

The infill walls increases the stiffness of the building. When buildings are subjected to deformation and concentration of forces, then the distribution of stiffness along the building plays an important role. Discontinuity in stiffness and mass may lead to failure of member at junction there by it results in the collapse of the structure. Buildings can have both symmetric and asymmetric plan. The lateral loads in a building are resisted by the frame structure i.e. by slab, beam, and column and then distributed to the footing and soil beneath.

When a moderate load acts on a structure, there is a separation between the infill panel and the frame. The infill act as a diagonal Strut (Figure 1), with the increase in the load there is a failure in the infill or in the frame. The usual failure mode will be due to tension in the windward column or due to shear in the beams or columns. But when the frame is designed to resist the entire ultimate load, then the failure begins in the infill panels. The diagonal Strut works on the principle that a truss will be formed by the loaded column and its diagonal along the infill; this truss formed structure will resist the in-plane lateral loads applied to the structure.

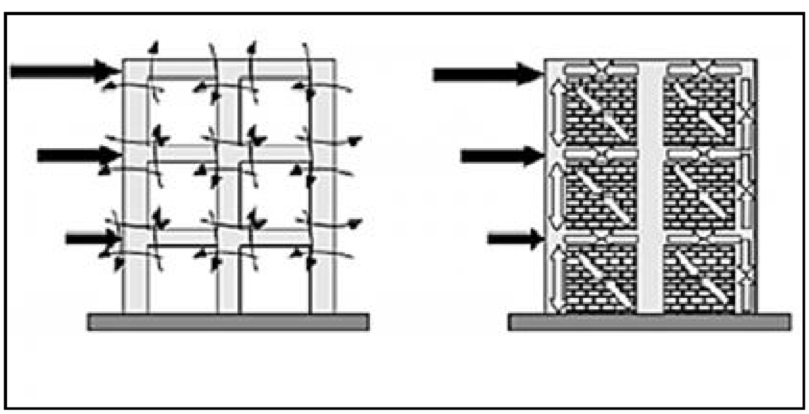


Figure1: Bare frame action and In-filled frame action

1.2. Membrane Action

If a slab is assigned as a membrane section, it has no out of plane stiffness and hence it cannot contribute to resist bending moment.

1.3. Shell Action

Considering the shell action on slab, both in plane and out of plane stiffness are considered. So assigning slab as shell will help in taking part the load along with the beam.

1.4. Response Spectrum Analysis

The objective of response spectrum analysis is to obtain the likely maximum response of the systems. The response spectrum is a plot of the maximum response (maximum displacement, velocity, acceleration or any other quantity of interest) to a specified load function for all possible single degree of freedom systems. The abscissa of the spectrum is the natural period (or frequency) of the system and the ordinate is the maximum response. It is also a function of damping. The design response of a spectrum given in IS 1893:2002 for a 5% damped system.

2. Modeling and Analysis of Building

In this paper, for analytical study multistory building is considered with soft storey at different level along with ground level. This building is modeled with infill wall and slab is considered as both membrane and shell. The analysis is carried out using ETABS V 2013.

2.1. Building Description

In this paper, for analytical study, a 25- storied (G+24) reinforced concrete building with irregular plan shape "L" in seismic zone V [IS 1893:2002] has been used for the present study.

The building considered for the study is asymmetric RC frame building plan with 9 bays of 5m in global X-direction and Y-direction. The plan area of the building is 45m x 45m with ground floor 4 m in height and remaining all story height is 3m each.

1. Size of the building: 45m X 45m
2. Grade of concrete : M25
3. Grade of steel : Fe 415
4. Ground floor height : 4m
5. Remaining floor to floor height : 3m
6. Slab thickness : 150mm
7. Wall thickness : 300mm
8. Size of columns
   800mm X 800mm (Base to Story10)
   600mm X 600mm (Story11 to Story20)
   500mm X 500mm (Story21 to Story 25)
9. Size of beam
   300mm X 300mm (Base to story 10)
   300mm X 250mm (Story11 to Story20)
   300mm X 200mm (Story21 to Story25)
10. Live load on floor : 3kN/m^2
11. Floor finish : 1.5kN/m^2
12. Roof treatment : 1.5kN/m^2
13. Seismic zone : 0.36 (For zone 5)
14. Soil condition : 2 (Medium)
15. Importance factor : 1.5

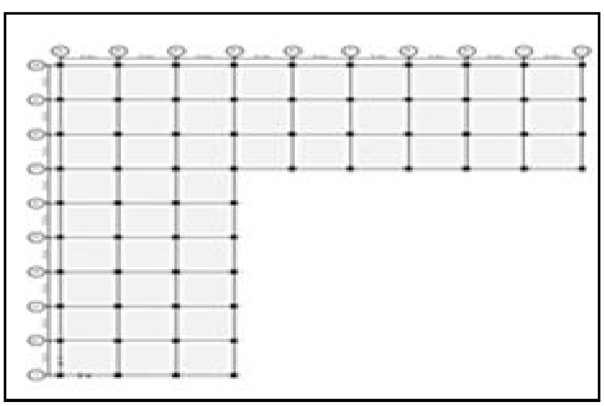


Figure 2: Plan of the building

Six models with soft storey (SS) at different levels are considered and these models were incorporated by assigning slab as membrane and shell.

- Model – 1(M1):- **SS (G):-** G+24 building with soft storey at Ground Level as shown in Figure 3
- Model – 2(M2):- **SS (5st):-** G+24 building with soft storey at 5th floor as shown in Figure 4
- Model – 3(M3):- **SS (10th):-** G+24 building with soft storey at 10th floor as shown in Figure 5
- Model – 4(M4):- **SS (15th):-** G+24 building with soft storey at 15th floor as shown in Figure 6
- Model – 5(M5):- **SS (20th):-** G+24 building with soft storey at 20th floor as shown in Figure 7
- Model – 6(M6):- **SS (25th):-** G+24 building with soft storey at 25th floor as shown in Figure 8

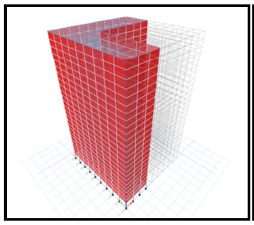


Figure 3: SS (G)

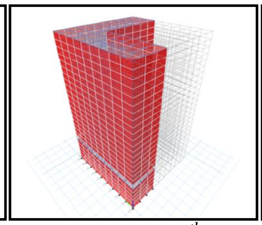


Figure 4: SS (5th)

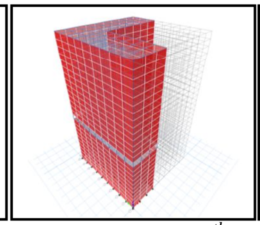


Figure 5: SS (10th)

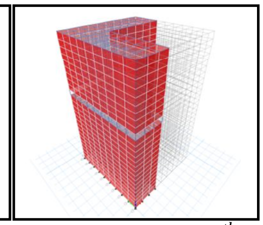


Figure 6: SS (15th)

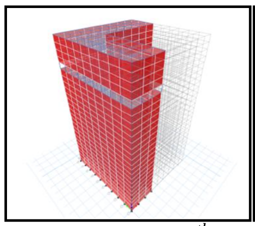


Figure 7: SS (20th)

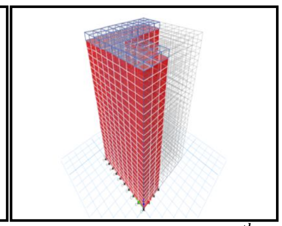


Figure 8: SS (25th)

3. Result and Discussions

3.1. Time Period

Time period for all the models are plotted below

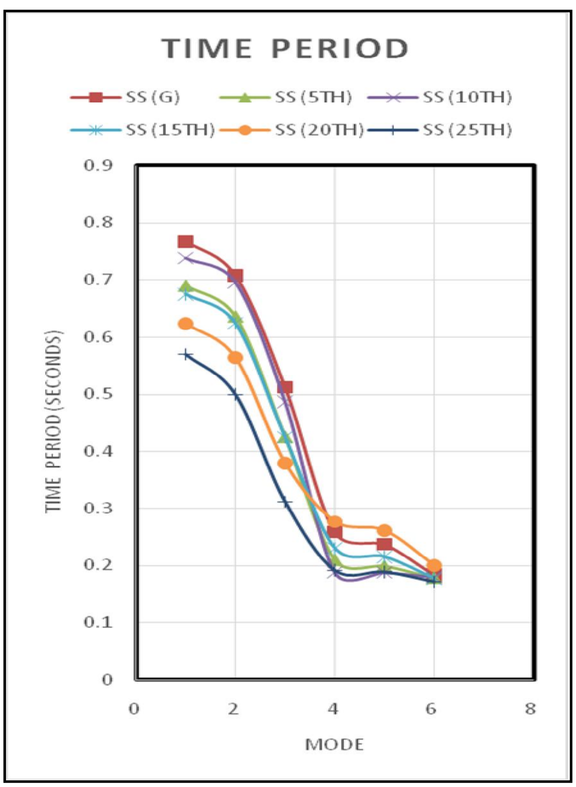


Figure 9: Time period considering slab as shell

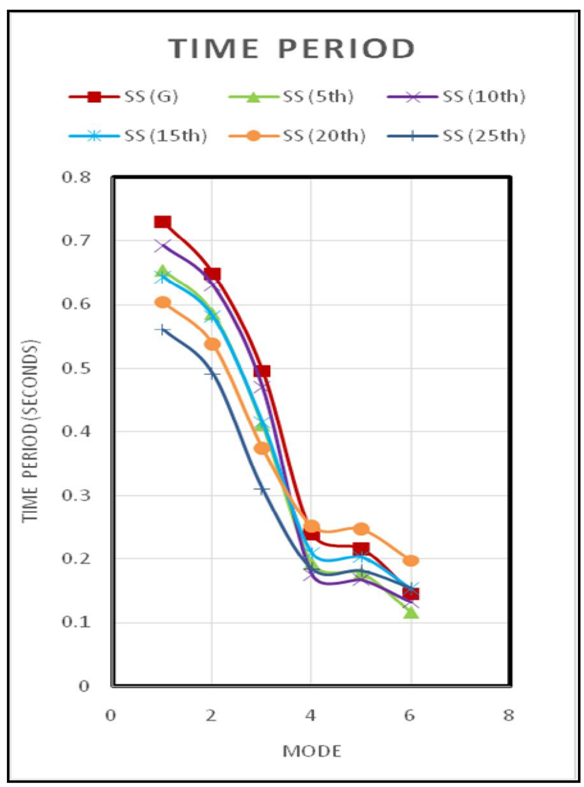


Figure10: Time period considering slab as membrane

3.2. Displacement

The introduction of infill wall in the RC frame structure reduces the lateral displacement. The displacement depends on the stiffness of the structure

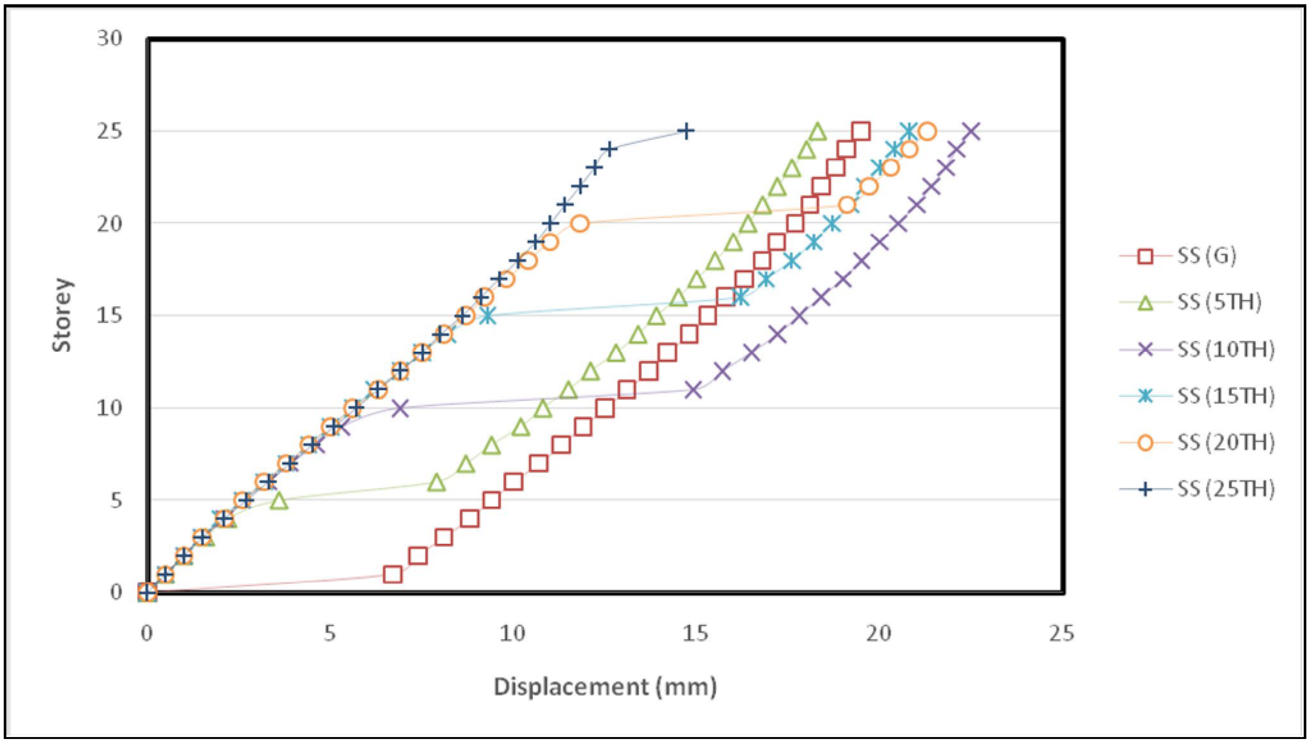


Figure 11: Displacement considering slab as shell

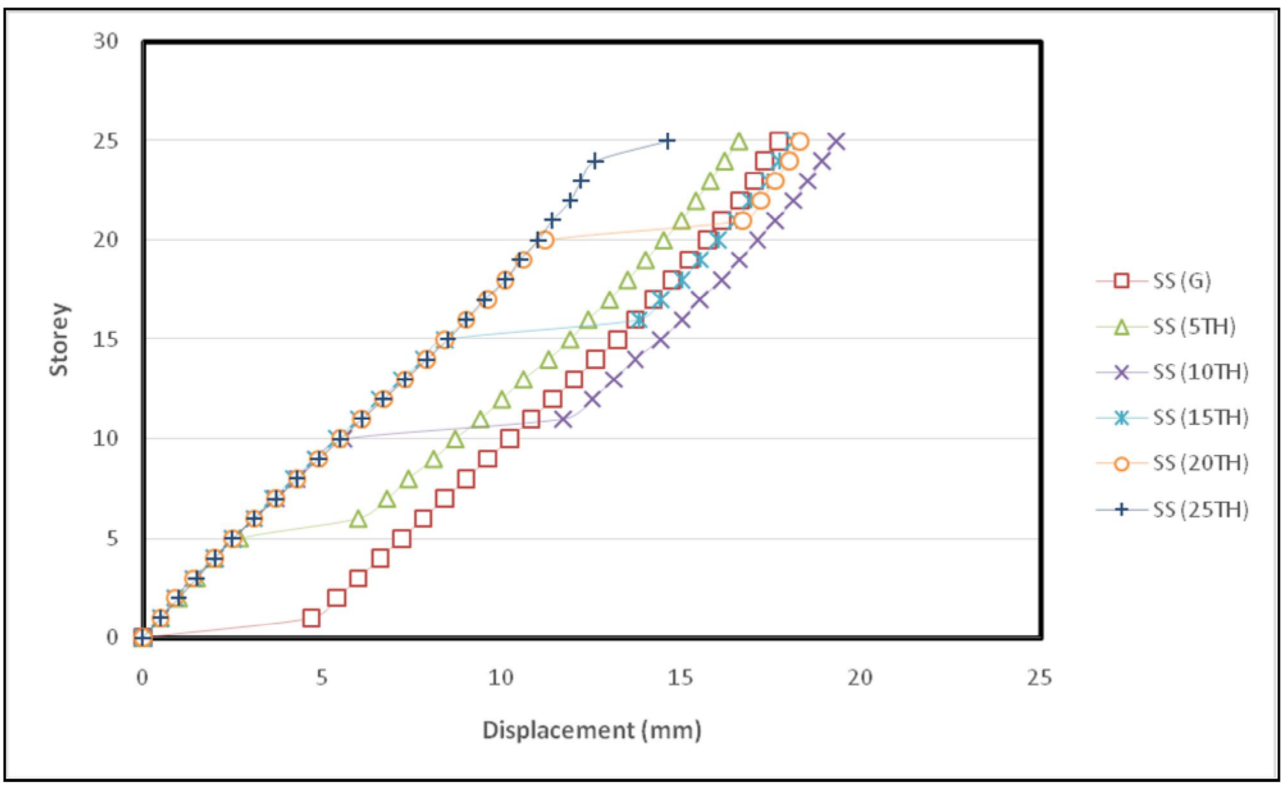


Figure 12: Displacement considering slab as membrane

Model number	Maximum displacement(mm) for shell slab	Maximum displacement(mm) for membrane slab
SS (G)	19.5	17.7
SS (5th)	18.3	16.6
SS (10th)	22.5	19.3
SS (15th)	20.8	18.1
SS (20th)	21.3	18.3
SS (25th)	14.7	14.6

Table 1: Maximum displacement values

Model number	Time period(seconds) for shell slab	Time period(seconds) for membrane slab
SS (G)	0.767	0.73
SS (5th)	0.69	0.654
SS (10th)	0.737	0.692
SS (15th)	0.675	0.643
SS (20th)	0.624	0.603
SS (25th)	0.569	0.56

Table 2: Time period values

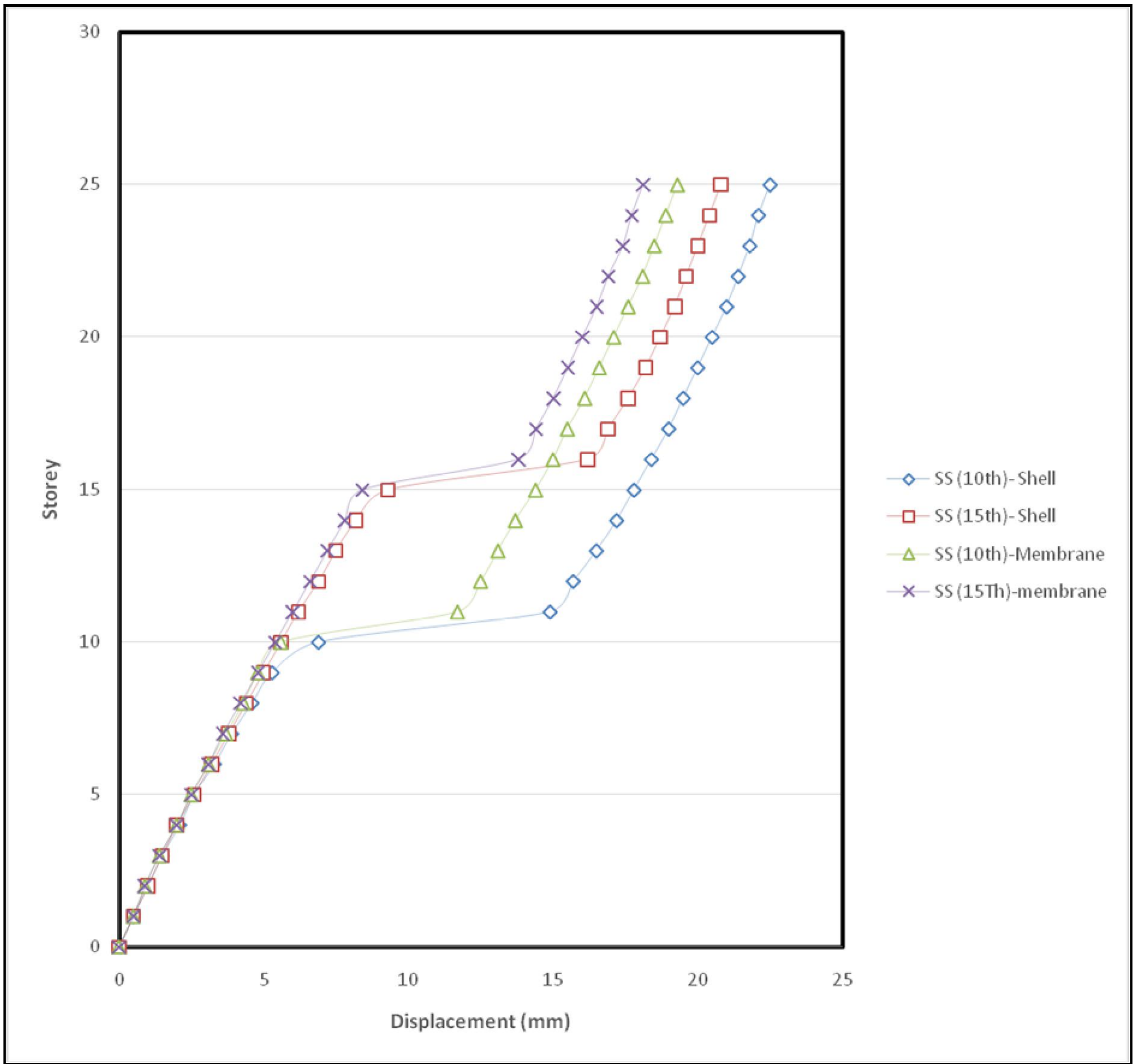
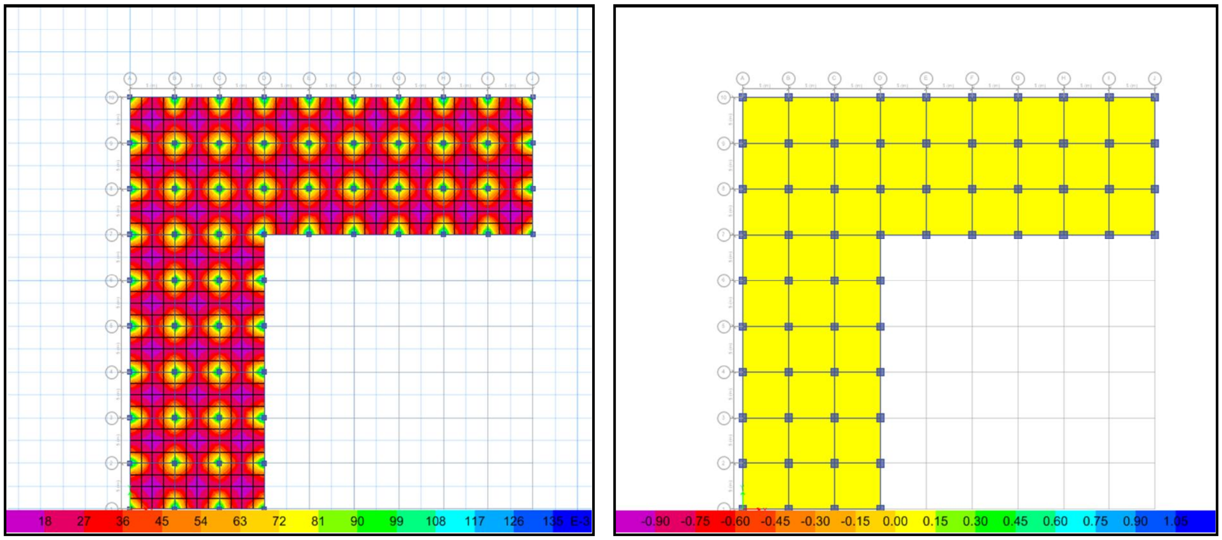


Figure 13: Displacement considering slab as shell and membrane for SS (10th) and SS (15th).

3.3. Slab Bending Moment

Since the membrane doesn't have out of plain stiffness, it cannot resist the bending moment, and hence the moment in slab will be equal to zero.

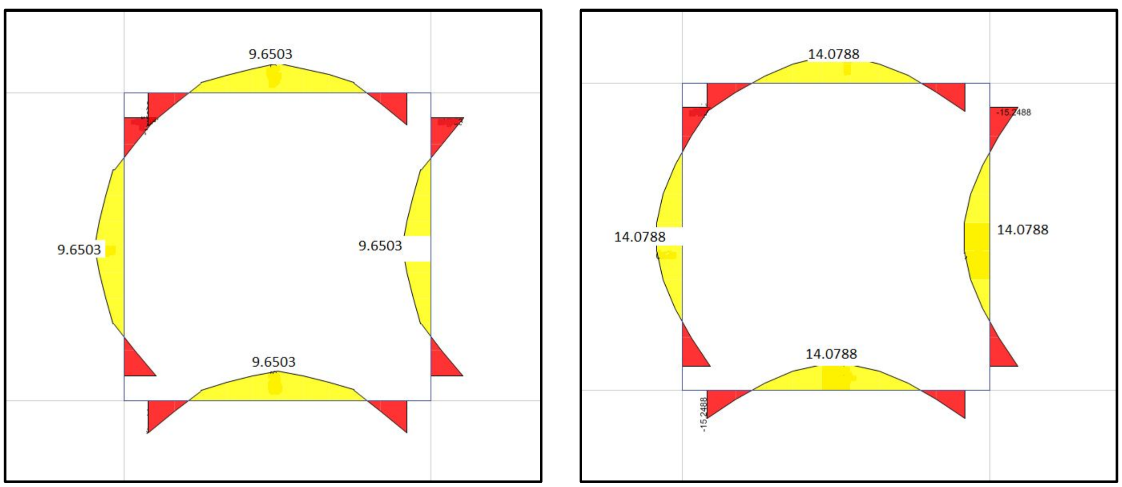


(a) (b)

Figure14: Bending moment contour developed on the slab by considering slab as (a) Shell and (b) membrane

3.4. Bending Moment on Beams

When slab is assigned as membrane and shell the plot of the bending moments in beams will be as below.



(a) (b)

Figure 15: Bending moment of beam when slab is assigned as: (a) Shell and (b) Membrane

4. Conclusions

i. Time period was found maximum for SS (G) and SS (10^{th}) models compared to other models.
ii. Time period was found less for slab as membrane compared to slab as shell.
iii. Models SS (20^{th}) and SS (25^{th}) are giving least displacement compared to other models.
iv. Model containing soft storey at 10^{th} floor has the largest displacement compared to the least displacement obtained for model with soft storey at 20^{th} and 25^{th} floor.
v. The displacement considering slab as shell for the model has a slight higher value compared to the value obtained by considering slab as membrane.
vi. Both time period and displacement were critical for the soft storey at middle height of structure.
vii. When slab is assigned as membrane, the slab bending moment will be equal to zero, compared to the values obtained when slab is assigned as shell.
viii. The model with slab as a membrane showing higher bending moment for the beams compared to the beams with slab as shell assignment.

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