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Evaluation of Flat Slab by Varying Percentage of Infill Wall in RC Building Using STAAD-Pro

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ABSTRACT

In the area of high seismicity the conventional slabs are become uneconomical due increase in design requirement to tackle additional seismic loads. The use of deep beams, increased column sections etc led to costly frame work. Moreover masonry infill wall effect is not incorporated in the design of conventional slab building frames, which led to unsafe or uneconomical design. These panels are used to fill gaps between the frames of building. Under seismic action these walls increases the strength and stiffness and reduces the time period by increasing the seismic mass of the building. This hinders the ductility requirement of the conventional frames which may lead to brittle failure under seismic action. To avoid this effect the flat slab systems are used. The flat slabs are the beamless frame having lower lateral stiffness, high storey drift, and are more flexible. But these are more susceptible to failure under seismic action.

Hence to avoid the failure of flat slab structure under seismic action, some lateral resistance structural elements are used in order to increase stiffness, reduce storey drift, lateral displacement thereby improving the lateral resistance of the system.

In the present study an attempt is made to analyze and study the various multi- storied reinforced concrete flat slab building frames with several percentage of infill wall considering the lateral resistance of flat slabs by evaluating parameters, subjected to seismic loading. A number of flat slab building frames are analyzed by varying the percentage of infill wall (0%, 50%, 80% and 100%) to evaluate parameters affected by the addition of infill wall in the flat slab. The results obtained by analysis are used to study and compare the effects of variable percentages of infill wall on the lateral resistance of flat slabs by varying storey height. The several parameters are compared for the lateral resistance assessment of flat slabs. The effect of masonry infill wall on flat slab frame in studied in terms of several parameters for the lateral resistance of the flat slab under seismic actions.

KEYWORDS: *Moment-resisting frames, Flat-slab, masonry infill panels, Equivalent static analysis; STAAD Pro, Reinforced Concrete*

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I. INTRODUCTION

The unavailability of spaces in the urban areas for the constructions due to increase in demand created vertical development of the structure, which includes low rise, medium rise and tall buildings. In order to develop these structure framed structure are used. They are subjected to both horizontal and vertical loads but longitudinal loads not playing important roles in designing and analysis of these structures. Due to increase in height and the loading intensity the designed structural requirement of conventional slabs changes. It includes increase in size of beams and column, increase in thickness of slab, increase in more rigidity of the joints. This led to undesired increase in lateral stiffness which hinders the performance of these slabs in seismic zones led to brittle failure and cracking. To overcome this problem flat slabs structures are used in which beams are not present.

II. OBJECTIVES OF RESEARCH WORK:

To study the physical and mechanical performance of industrial waste polymer fiber used in the concrete mixtures.

1. To evaluate the effect of flat slabs with variable percentage of infill wall on Lateral Load,
2. To evaluate the effect of flat slabs with variable percentage of infill wall on Storey Shear,
3. To evaluate the effect of flat slabs with variable percentage of infill wall on Lateral Displacements,
4. To evaluate the effect of flat slabs with variable percentage of infill wall on Storey Drift,
5. To evaluate the effect of flat slabs with variable percentage of infill wall on Drift ratio.

III. LITRATURE RIVEW

Soni et al. (2019) studied the nonlinear analysis of moment resisting frames under dynamic excitation compared the base shear and time period of multi storey moment resisting frames of various configuration with varying height by using STAAD.pro software. The base shear of different modal combination methods for different configuration is also studied. The combination methods includes SRSS (Square Root of Summation of Squares method), 10PCT (10 per cent method), ABS (Absolute sum method) and CSM (Closely-Spaced Modes grouping method). The storey height varied from ground level to G+ 11 storey for different multi bay and varied column seize configuration. They analyzed models for each storey and each configuration to study the structural response. They found that the time period and base shear play significant role in design of structure. It was also found that the time period of the structure also depends upon several parameters configuration. The base shear computed from SRSS method gives more conservative value than other methods. It was also observed that for lower height of building the difference in base shear with reference to SRSS method are height and the difference decreases with the increase in height of the building.

Mahfujur.et.al (2021) Structure Analysis and Design is an important part of the Civil Engineering Division. Analysis and Design of slab plays a vital role in Structural Engineering practice to ensure infrastructural sustainability, durability and economic lucrativeness. Two- way slab analysis is the preeminent segment for structural engineers. Effective analysis and design of two-way slab structural element is the proportionate with the project cost. This paper also discusses calculate the moment coefficient of two-way slab for different types of two slab condition by use Structural analysis & Design software (STAAD Pro.-2006) and comparison of calculated moment coefficients values with corresponding American Concrete Institute (ACI-318-14) values. Create a two-way slab model by use STAAD. Pro-2006 software for different case (As per ACI-318-14) and disparate ratio to applied uniform load on the model and calculate the coefficient data. The result data are complied with the American Concrete Institute (ACI-318-14).

Vignesh et al. (2021) Tall buildings are prone to heavy damage due to lateral loads namely seismic and wind load. This damage causes a heavy loss of life. In order to improvise the standards of the building by introducing shear walls. A study was made using STAAD Pro V8i to study the deflection, Bending moment, Shear force caused due the Earthquake and wind load and on..

METHODOLOGY:-

In clay water mixture positively charged ions (cat-ions) are present around the clay particles, creating a film of water To achieve the objectives of present study STAAD Pro software are considered for the parametric study of the flat slab building with variable percentage of infill wall. For the present study four different models of flat slab with infill wall are considered.

1. Flat slab with 0% infill walls
2. Flat slab with 50% infill walls
3. Flat slab with 80% infill wall
4. Flat slab with 100% infill wall

The above four models is analyzed for 10 storey building. The modeling and analysis are done with the aid of software STAAD-PRO V8i in acquiescence with the codes IS: 456- 2000 and IS: 1893-2002. The total 4 models of flat slabs with infill walls for 10 storey building is analyzed by using STAAD Pro software to obtain the seismic parameters including storey shear, lateral displacement, storey drift, drift ratio and lateral load.

The methodology worked out to achieve objectives of the study is as follows:

1. Select a suitable flat slab building model of 10 storeys.
2. Model the selected buildings of flat slabs with 0%, 50%, 80% and 100% infill walls.
3. Equivalent static analysis of the selected building models and a comparative study on the parameters obtained from the analyses to evaluate the effect of percentage infill on the flat slab frame

IV. GEOMETRIC AND MATERIAL PROPERTIES

Since all the models of flat slab for different storied building with particular percentage of infill wall, looks similar except the number of storey. The plan for 10 storey building with no infill, 50% infill, 80% infill and 100% infill shown in fig 4.1, fig 4.4, fig 4.7 and fig 4.10 The elevation for 10 storey building with no infill, 50% infill, 80% infill and 100% infill shown in fig 4.2, fig 4.5, fig 4.8 and fig 4.11 The isometric view for 10 storey building with no infill, 50% infill, 80% infill and 100% infill shown in fig 4.3, fig 4.6, fig 4.9 And fig 4.12.

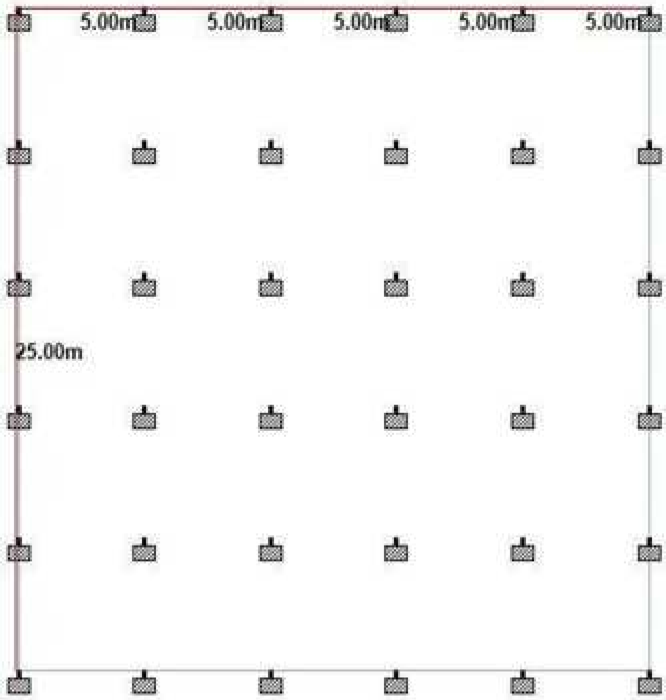

Figure 4.2: Elevation of flat slab building having no infill walls.

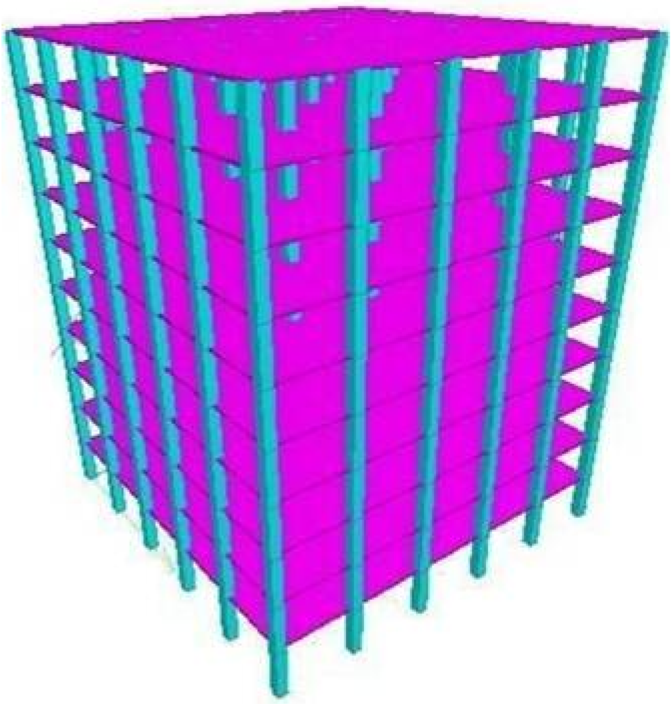

Figure 4.3: Isometric view of flat slab building having no infill walls

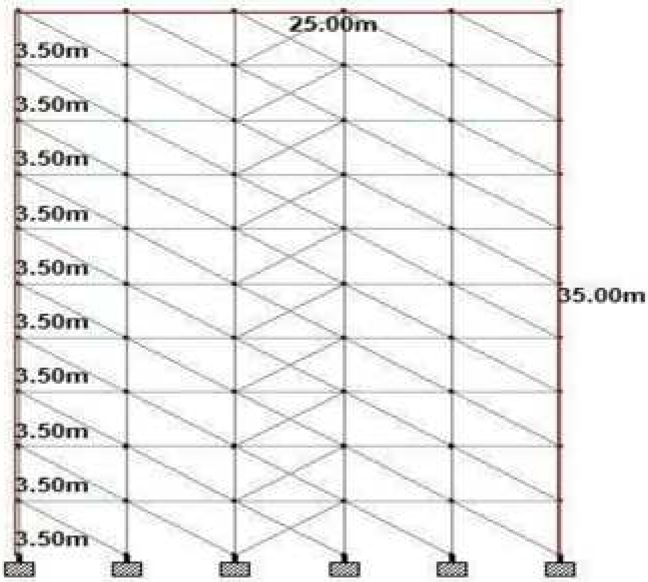

Figure 4.4: Elevation of flat slab building having 80 % infill walls

Table 4.2: Geometric properties of building frame model

S. No.	Description	values
1	No. of storey	10 storey
2	Plan dimensions	25m * 25m
3	Number of bays in X-direction	5
4	Number of bays in Z-direction	5
5	Bay width in X-direction	5m
6	Bay width in Z-direction	5m
7	Floor to floor height	3.5m
8	Size of Column	600 mm * 600 mm
9	Slab thickness	200 mm
10	Thickness of wall	230 mm
11	Width of equivalent strut	564 mm

Table 4.3: Material properties

S. No.	Description	values
1	Concrete grade	M-25
2	Density of reinforced cement concrete	25kN/m3
3	Young's modulus of concrete, Ec	$2.5x10^4$ N/mm^2
4	Poisson ratio of concrete, μ	0.2
5	Young's modulus of brick, Ec	$1.38x10^4$ N/mm^2
6	Poisson ratio of Brick, μ	0.15

LOADING AND LOAD COMBINATIONS

In the present study dead load, live load and seismic load is considered for analysis and design. The seismic load is taken as per IS: 1893–2002 Criteria for Earthquake Resistance Design of Structures. The various parameters taken for seismic load calculation are shown in table 4.3.

Table 4.4: Various parameters for seismic load calculation

S. No.	Parameters	value
1	Seismic zone	III
2	Response reduction factor	3
3	Importance factor	1.5
4	Soil site factor	2 (medium soil)
5	Damping ratio	0.05
6	Type of Structures	1

GEOMETRIC AND MATERIAL PROPERTIES

Since all the models of flat slab for different storied building with particular percentage of infill wall, looks similar except the number of storey. The plan for 10 storey building with no infill, 50% infill, 80% infill and 100% infill shown in fig 4.1, fig 4.4, fig 4.7 and fig 4.10 The elevation for 10 storey building with no infill, 50% infill, 80% infill and 100% infill shown in fig 4.2, fig 4.5, fig 4.8 and fig 4.11 The isometric view for 10 storey building with no infill, 50% infill, 80% infill and 100% infill shown in fig 4.3, fig 4.6, fig 4.9 And fig 4.12.

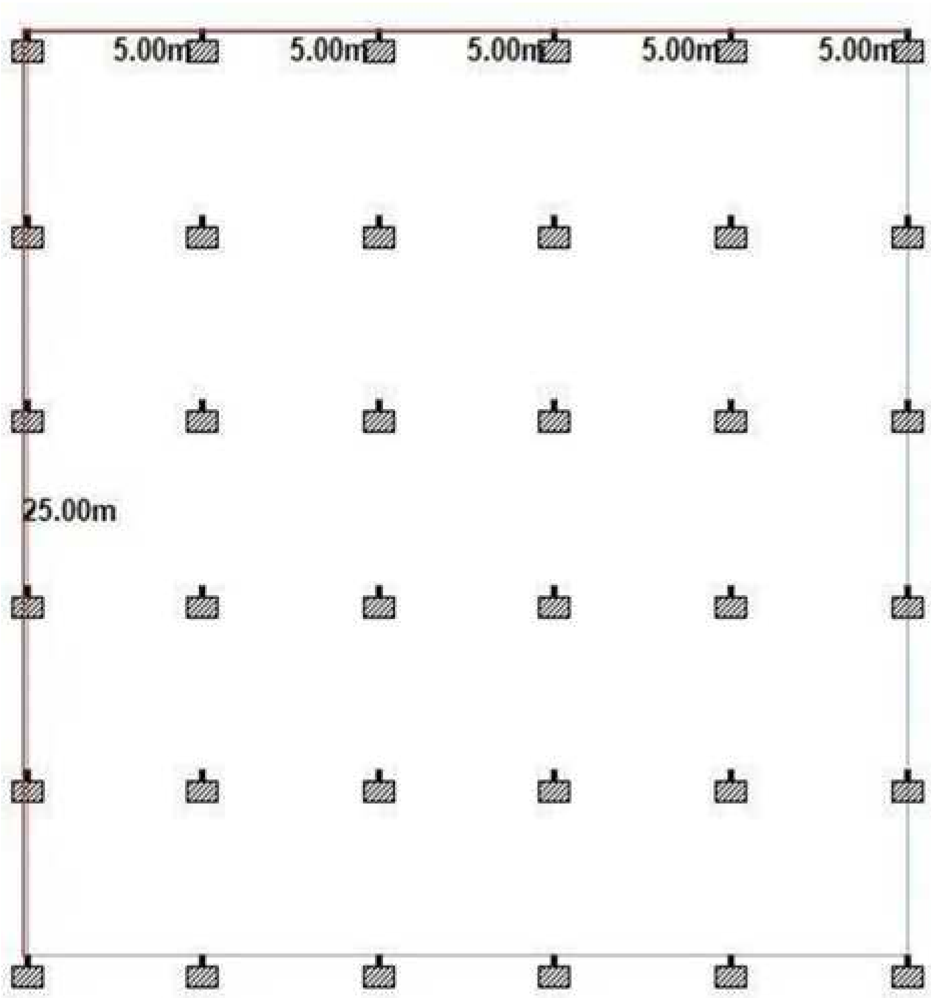

Figure 4.1: Plan of flat slab building having no infill walls.

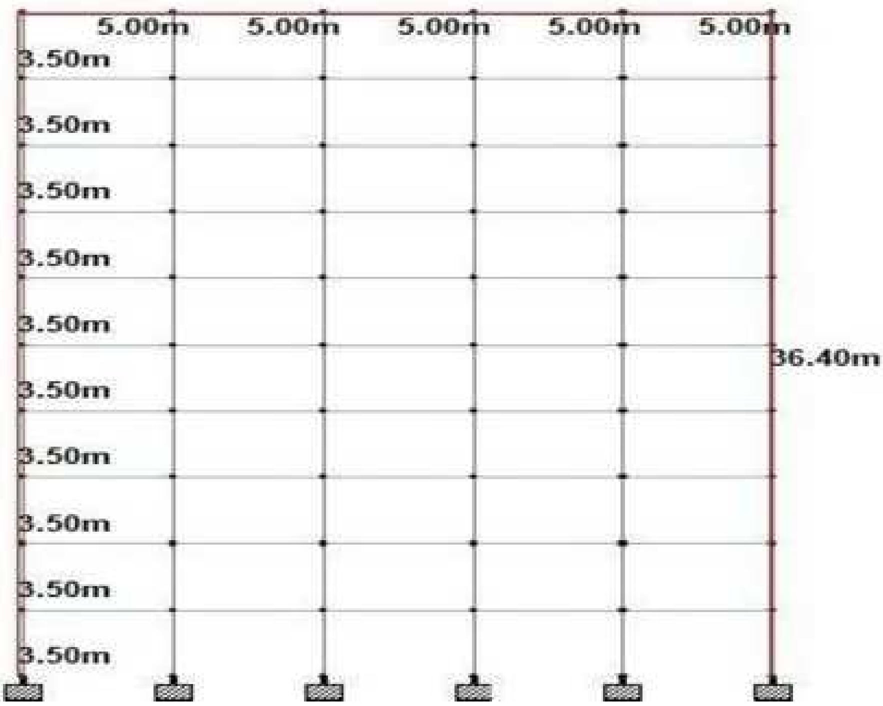

Figure 4.2: Elevation of flat slab building having no infill walls.

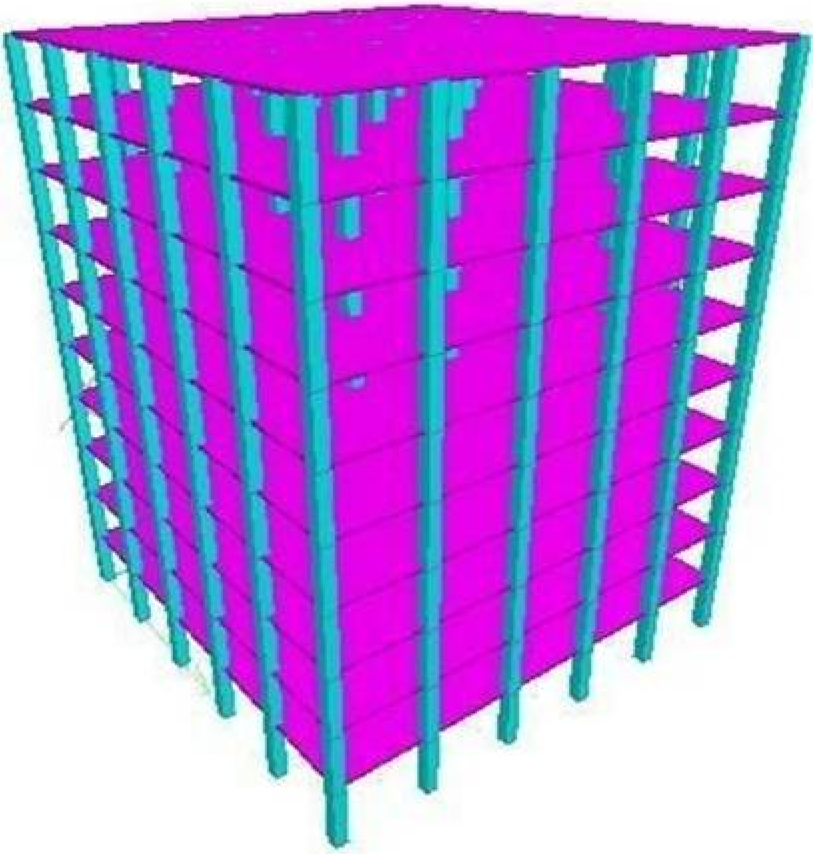

Figure 4.3: Isometric view of flat slab building having no infill walls

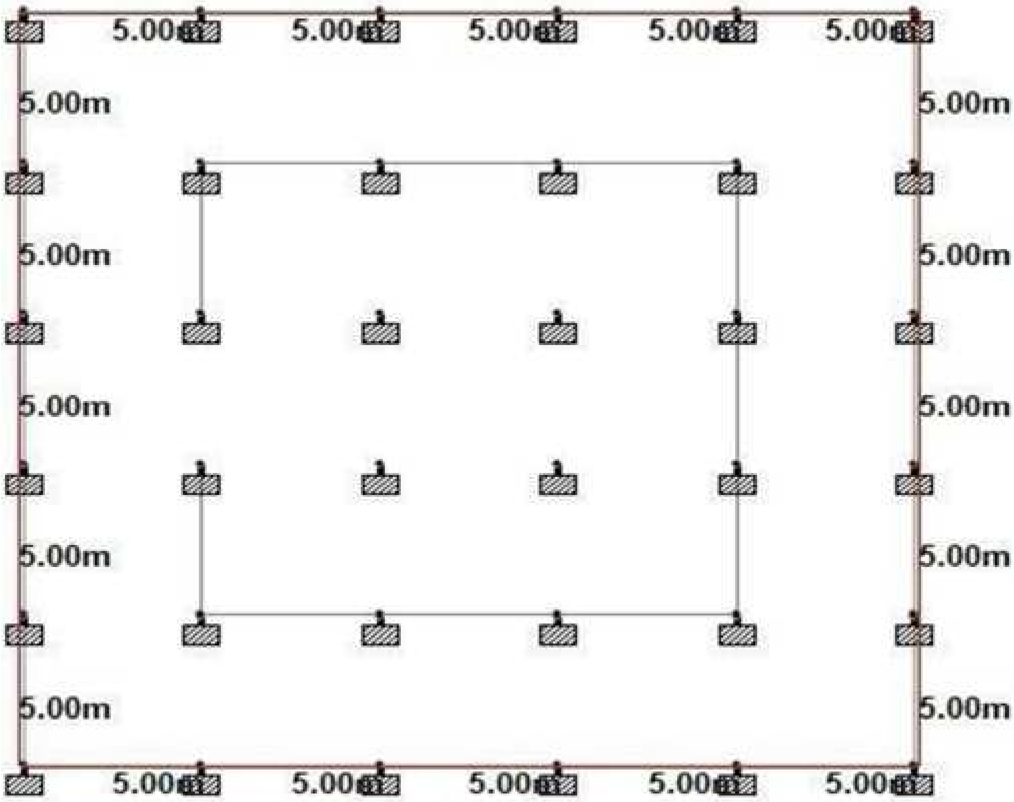

Figure 4.4: Plan of flat slab building having 50 % infill walls

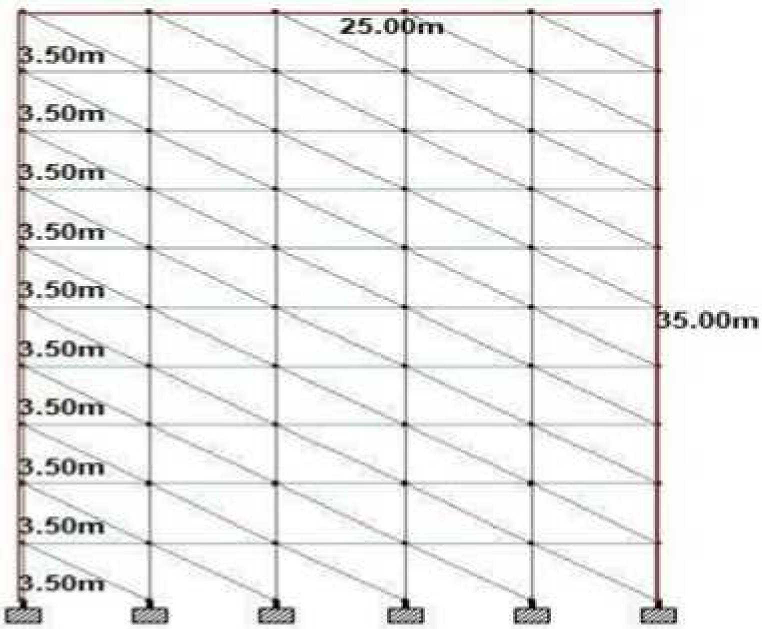

Figure 4.5: Elevation of flat slab building having 50 % infill walls

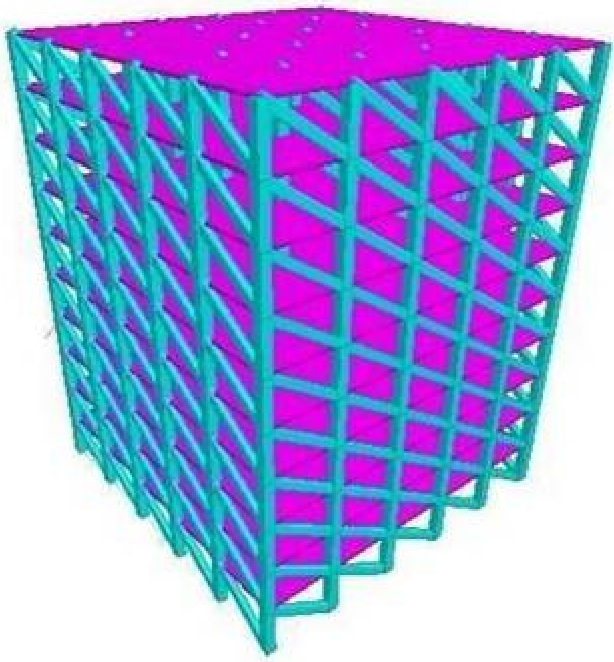

Figure 4.6: Isometric view of flat slab building having 50 % infill walls

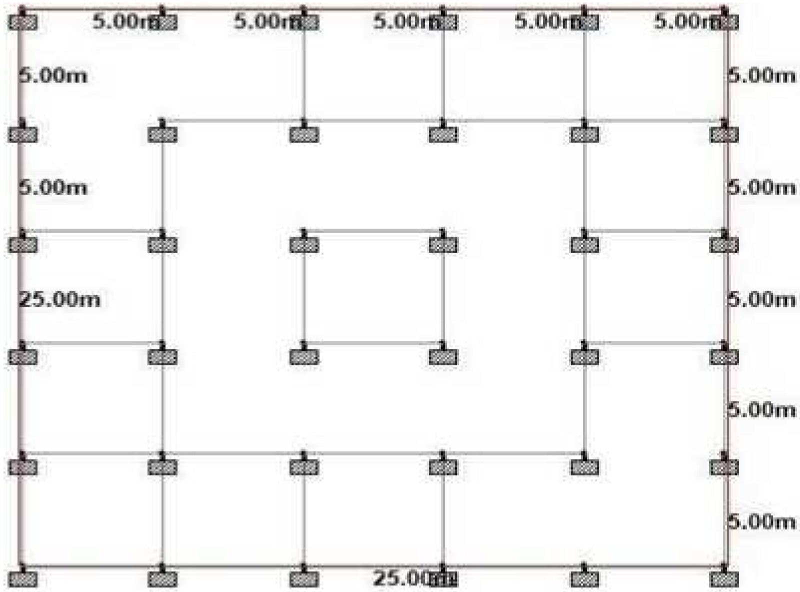

Figure 4.7: Plan of flat slab building having 80 % infill walls

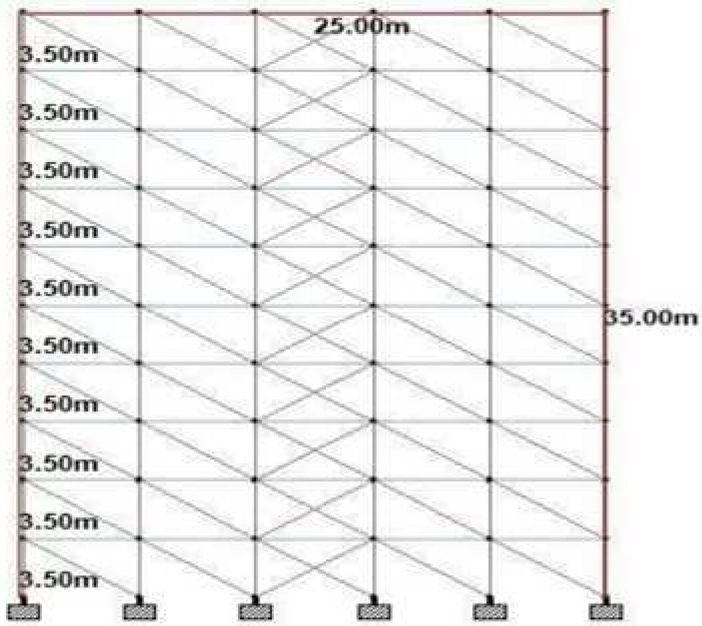

Figure 4.8: Elevation of flat slab building having 80 % infill walls

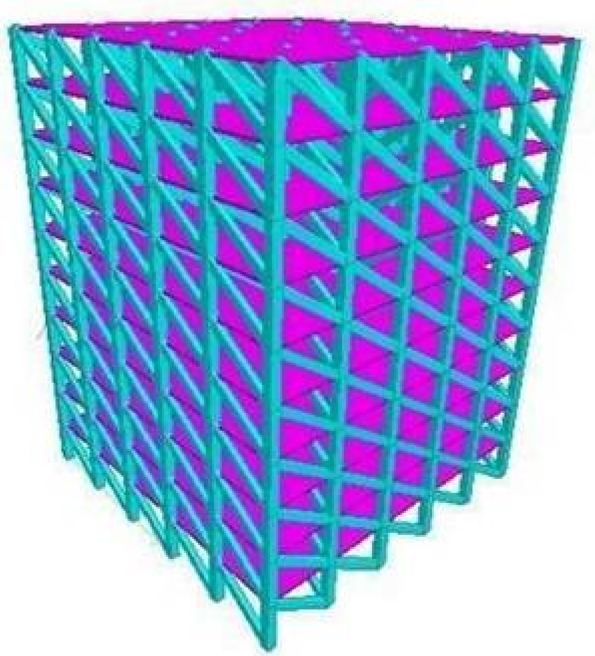

Figure 4.9: Isometric view of flat slab building having 80 % infill walls

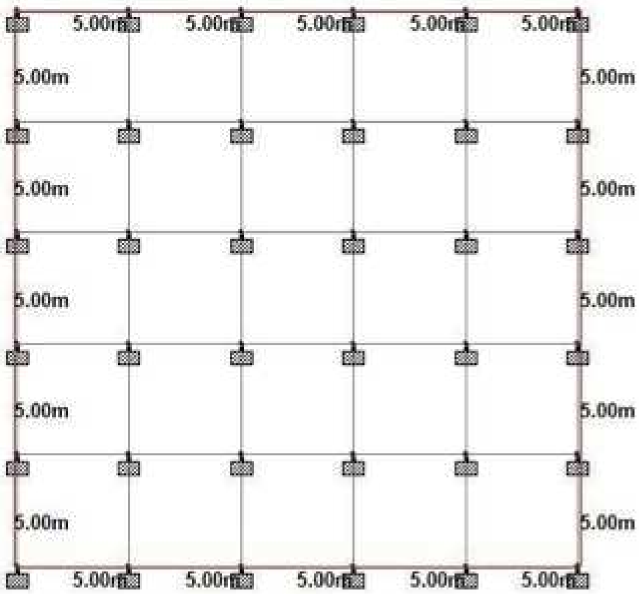

Figure 4.10: Plan of flat slab building having 100 % infill walls

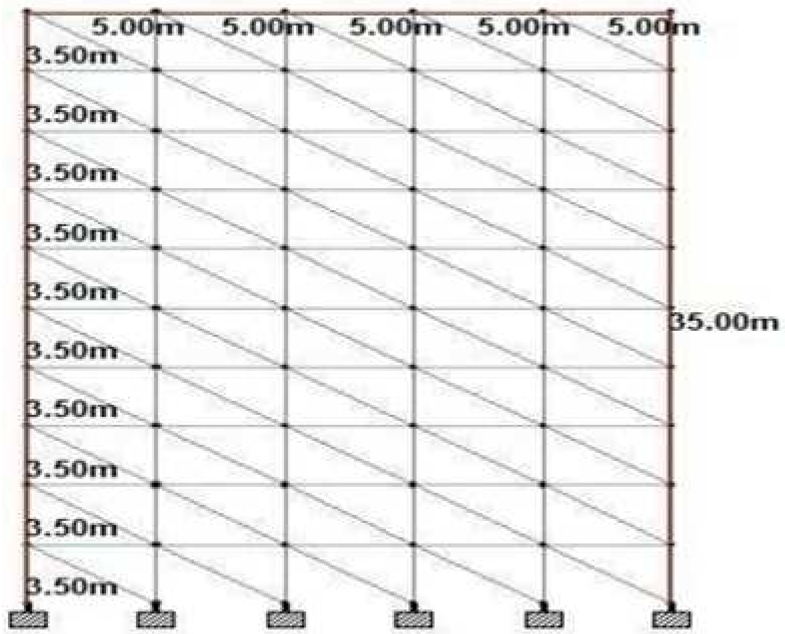

Figure 4.11: Elevation of flat slab building having 100 % infill walls

The properties considered for modeling and analysis of building frames are shown in the table 4.2 and table 4.3.

Table 4.2: Geometric properties of building frame model

S. No.	Description	values
1	No. of storey	10 storey
2	Plan dimensions	25m * 25m
3	Number of bays in X-direction	5
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5	Bay width in X-direction	5m
6	Bay width in Z-direction	5m
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LOADING AND LOAD COMBINATIONS

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S. No.	Parameters	value
1	Seismic zone	III
2	Response reduction factor	3
3	Importance factor	1.5
4	Soil site factor	2 (medium soil)
5	Damping ratio	0.05
6	Type of Structures	1

EQUIVALENT STATIC ANALYSIS RESULTS

The static seismic analysis is performed for all models and in the following section results are discussed.

➢ Lateral load

Comparison of lateral load at different story for flat slabs with 0 % (FS), 50 % (FS 50%), 80 % (FS 80%) and 100 % (FS100%) infill walls models for 10 storey building are shown in table and Fig 5.1.

Table 5.1: Comparison of lateral load (kN) at different story among four models for 10 storey building

Storey no.	Lateral Load (in kN)			
	FS	FS 50%	FS 80%	FS 100%
1	5.444	6.967	7.595	8.314
2	21.774	27.866	30.38	32.536
3	48.992	62.699	68.355	73.206
4	87.097	111.465	121.519	130.143
5	136.089	174.165	189.874	203.349
6	195.967	250.797	273.418	292.822
7	266.734	341.363	372.152	398.563
8	348.387	445.862	486.077	520.573
9	440.927	564.294	615.191	658.85
10	471.885	552.113	584.8	612.701

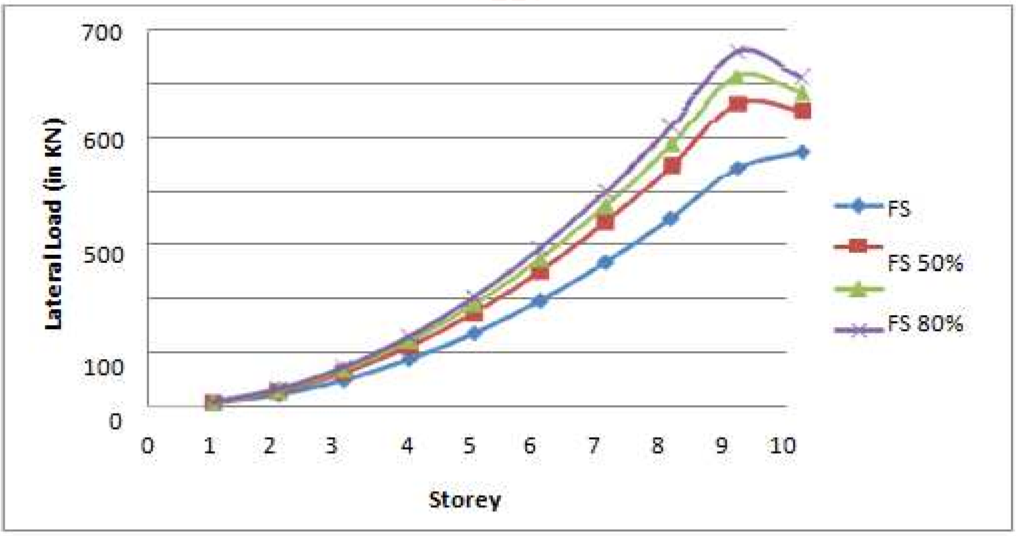

Figure 5.1: Lateral load (kN) at different storey for four models for 10 storey building

The table 5.1 and fig 5.1 indicates that FS 100% infill wall has maximum lateral load when compared to lower percentages of infill. Lateral load for FS 100% for the top storey for 10 storey building is 1.29 times the flat slab with no infill model. Lateral load for FS80% is 1.26 times and for FS50% it is 1.16 times as compared to no infill case and lateral load for all models increase from base and maximum at top storey.

➢ Storey shear

Comparison of storey shear at different story for flat slabs with 0 % (FS), 50 %(FS 50%), 80% (FS 80%) and 100 % (FS100%) infill walls models for 10 storey building are shown in table and Fig 5.2.

Table 5.2: Comparison of storey shear (kN) at different story among four models for 10 storey building

Storey no.	Storey Shear (in kN)			
	FS	FS 50%	FS 80%	FS 100%
1	2023.3	2537.59	2749.36	2931.06
2	2017.85	2530.62	2741.77	2922.74
3	1996.08	2502.76	2711.39	2890.21
4	1947.09	2440.06	2643.03	2817
5	1859.99	2328.59	2521.51	2686.86
6	1723.9	2154.43	2331.64	2483.51
7	1527.93	1903.63	2058.22	2190.69

8	1261.2	1562.27	1686.07	1792.12
9	912.812	1116.41	1199.99	1271.55
10	471.89	552.113	584.8	612.701

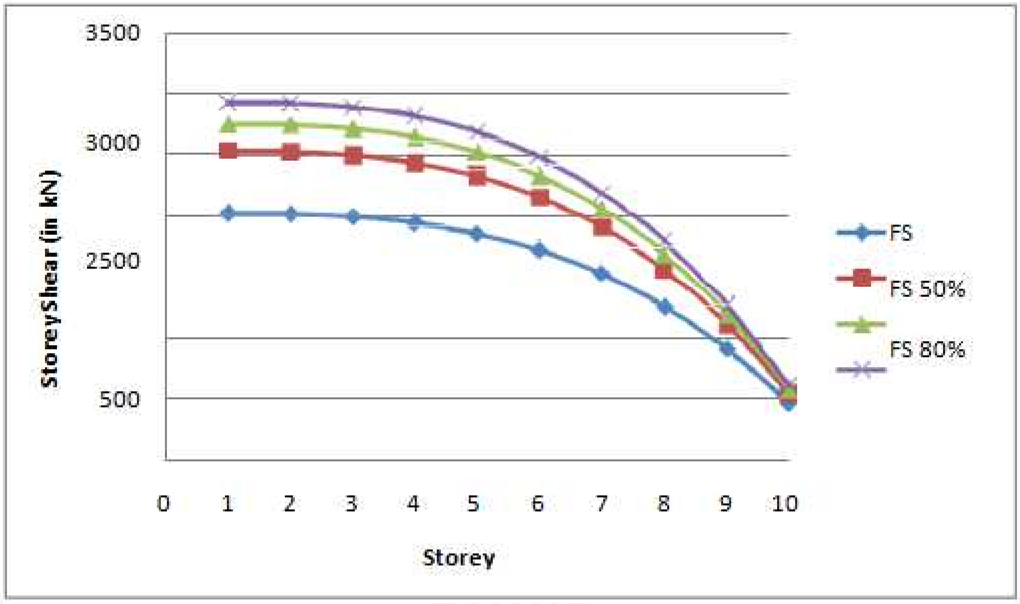

Figure 5.2: Storey shear (kN) at different story for four models for 10 storey building

The table 5.2 and Fig 5.2 indicates that storey shear for FS 100% for the bottom storey for 10 storey building in is 1.44 times the flat slab with no infill model. Storey shear for FS80% is 1.35 times and for FS50% is 1.25 times the no infill case and storey shear for all models increase from top and maximum at bottom storey i.e. at base.

V. CONCLUSION

A ten storied models of reinforced concrete flat slab building frame with Zero % infill walls, 50% infill walls, 80% infill walls and with 100% infill walls are analyzed in STAAD Pro software considering the effects of seismic parameters on flat slab. To achieve the objectives 4 models of flat slab 0% infill, 50% infill, 80% infill and 100% infill for 1^{st}, 2^{nd}, 3^{rd}…..up to 10th Storey buildings are analyzed by STAAD Pro software and results are compared among different models in the chapter of result and discussion Based on the results and discussions followings conclusions are drawn.

Lateral load

The lateral load of flat slab with 100% infill wall has maximum value as compared to 80, 50 and zero percentage infill in 10 storey building. The infill wall addition increases the overall weight of structure which increases the lateral loads. The lateral load increases from base and maximum at the top storey.

Storey shear

The storey shear for flat slab with 100% infill wall has maximum value as compared to 80, 50 and 0 % infill in 10 storey building. The storey shear increases from top and maximum at bottom storey i.e. at base

Lateral displacement

The lateral displacement for flat slab with no infill walls at the top storey has maximum value when compared to 100, 80 and 50 percentage infill in 10 storey building. The infill wall addition increases the stiffness of the flat slab building. The lateral displacement increase from bottom and maximum at top storey.

Storey drift

The storey drift for flat slab with no infill wall at the top storey has maximum value when compared to other percentage infill models of flat slabs in 10 storey building. The storey drift for flat slab with no infill case follows more nonlinear behavior than 100% infill case due to lack of lateral stiffness.

Drift ratio

The drift ratio for flat slab with 0% infill model for the top storey model has maximum value when compared to other percentage infill models of flat slabs in 10 storey building. The drift ratio for flat slab with no infill case follows more nonlinear behavior than other infill case.

SCOPE FOR FURTHER STUDY

In the future study the effect of seismic parameters is carried out for three different storey (five, ten and fifteen storey) flat slab regular plan building for different percentages of infill walls i.e. 0%,50%, 80% and100 % infill wall using single equivalent diagonal struts model for infill walls under seismic loading. Following points may be considered for further analysis of the present work.

- The analysis can be extended for more parameters.

- The structure can be analyzed for more percentage of infill wall variation.
- The flat slab with drop panel and column heads can also be analyzed.
- The infill wall panel can be analyzed and modeled for nonlinear techniques.
- The structure can be analyzed for different seismic zones.

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