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Seismic Response of Large span slab in Horizontal Setback Building

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***Abstract:** The demand for multi-storey buildings is increasing day by day. Residential plus commercial building is mainly used for wide span needs. Wide span required for Flat slab, Waffle slab and ribbed slab stands An excellent option for architects when larger openings in a building need to be covered with as few columns as possible. The use of different types of plates is developing as a new trend and is becoming a major challenge for structural engineers. Therefore, it is necessary to study about its structural behavior. The project is carried out under earthquake zone III under the earthquake analysis of G+9 storey building. For this study, four different types of large span slab structure are modelled in C-shape (Horizontal Setback Building) having 10-stories i.e. G+9 storied buildings with 3.50 meters height for each story is modelled and analysed. The plan area of all four buildings is same i.e. 2859 square meters (49.50 m x 82.50 m) each. These buildings were designed in compliance with the Indian Code of Practices for earthquake resistant design of buildings. Base of the building were fixed. The square sections are used for structural elements. The height of the buildings is considered constant throughout the structure. The buildings are modelled using ETABSvr.2016.*
***Keywords:** large span slab, ETABSvr.2016, Horizontal Setback Building, Flat slab, Waffle slab and ribbed slab*

I. INTRODUCTION

Horizontal setback buildings are prone to suffer significant damage during seismic excitation due to in-plane soil flexibility, which affects performance in two ways: the first one is change the lateral force distribution between the lateral load-bearing members; and second one is causes excessive stress concentration at the re entrant corners. Recoil structures are highly susceptible during earthquakes due to their vertical geometric and mass irregularity, but the fragility is further increased if the structures also have stiffness irregularities. If the structure is on a sloping ground, the risk factor of this structure may increase. In this paper, the seismic performances of regression structures sitting on flat ground as well as on the slope of a hill with a soft storey configuration were evaluated. The analysis was carried out in three different methods, namely the equivalent static force method, the response spectrum method and the time domain method, and the extreme responses were recorded for the open ground storey inverted building. To reduce this soft fold effect and overreactions, three different reduction techniques were adopted and the best solution from these three techniques was presented.

The horizontal setback building consist is also enhance the effect of the building under various types of slabs are used. The Slabs are constructed to provide flat surfaces, usually horizontal in building floors, roofs, bridges, and other types of structures. The slab may be supported by walls or by reinforced concrete beams usually cast monolithically with the slab or by structural steel beams or by columns, or by the ground. The basically slabs are used as normal, waffle, ribbed and waffle slab.

II. OBJECTIVES OF THE PROJECT

The following objectives are taken in this project

1) To study the behavior of different types of slab & secondary beam in a structure.
2) To Study the various past research based on use of various slabs and secondary beam..
3) To Modelled a G+9 multistory building under taking different variation on slabs & introduce a secondary beam in the structure.
4) To compare a different models case to find optimized structure.
5) To analysis G+9 multistory building by RSA (Response Spectrum Analysis).
6) To assist the different parametric result such as Storey displacement, base shear, overturning moments, storey shears etc into it.

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III. METHODOLOGY AND MODELLING

Modeling and analysis of this research is done in CSi ETABS software. For complex structural analysis, a software like CSi ETABS helps in visualization of the structural model and also deprive the tedious calculation of the analysis results in complex structures like the structures under consideration in this study. The table 1 is explained the model cases used on in this project.

Table 1: Model Description

S. No.	Model Description	Structure Description
01	Model 1	Building having Flat Slab with Drop Panels
02	Model 2	Building having Waffle Slab
03	Model 3	Building having Ribbed Slab
04	Model 4	Building having Secondary Beams

A. *Structural & Material Properties*

Table 2 and 3 enlist the structural and material properties respectively.

Table 2: Structural Properties

Structural Properties		
S. No.	Descriptions Of Parameters	Dimensions / Comments
A)	Common Parameters	
1	Structure type	Rigid frame Buiding
2	No of storey /total height	G+9 /35.00 m
3	Plan area	49.50 m x 82.50 m
4	Column size	600 mm x 600 mm
5	Spacing in grid in x –direction	8.25 m. c/c
6	Spacing in grid in y –direction	8.25 m. c/c
8	Individual storey height	3.50 m.
B)	Model 1: Building Having Flat Slab with Drops	
1	Beam Size	No beams
2	Slab Thickness without Drop	285 mm
3	Slab thickness with Drops	360 mm
4	Drop Size	3.00 m x 3.00 m
5	Thickness of Drops	75 mm
C)	Model 2: Building Having Waffle Slab	
1	Beam Size	400 mm x 700 mm
2	Slab Thickness	150 mm
3	Overall Slab thickness	450 mm
4	Stem Width	250 mm
5	Spacing of Stems in X-Direction	1500 mm c/c
6	Spacing of Stems in Y-Direction	1500 mm c/c
D)	Model 3: Building Having Ribbed Slab	
1	Beam Size	400 mm x 700 mm
2	Slab Thickness	150 mm
3	Overall Slab thickness	450 mm
4	Stem Width	250 mm
5	Spacing of Stems in X-Direction	1500 mm c/c
E)	Model 4: Building Having Secondary Beams	
1	Beam Size	400 mm x 700 mm
2	Slab Thickness	150 mm
3	Secondary Beam Size	250 mm x 400 mm
5	Spacing of Beams in X-Direction	2000 mm c/c

Table 3: Material Properties

Material Properties		
S. No.	Types of material	Dimensions / comments
1	Concrete (beam & column)	M-30
2	Concrete (Slab)	M-25
3	Grade of rebar (R/F)	HYSD-500

Figure 1 and figure 2 represent the Plan and 3-D view of the Model 1 & 2. Figure 3. to figure 4 depicts the plan and 3d of each model similarly.

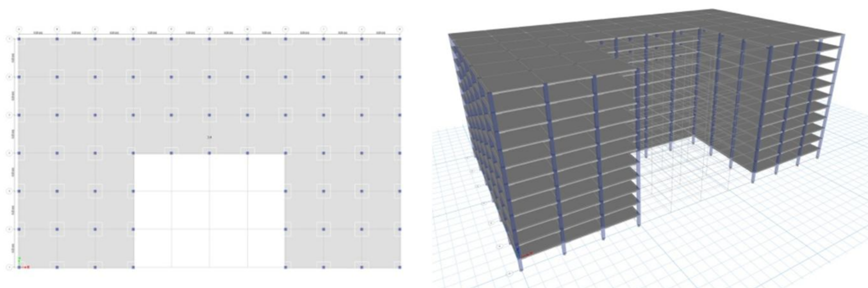

Fig. 1: Model 1: Building with Flat Slab a) Plan b) 3D model

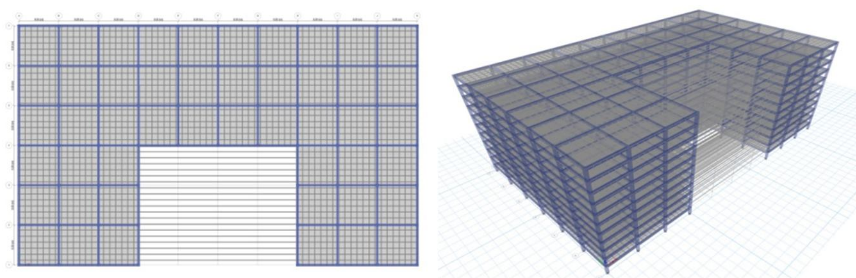

Fig. 2: Model 2 Building with Waffle Slab a) Plan b) 3D model

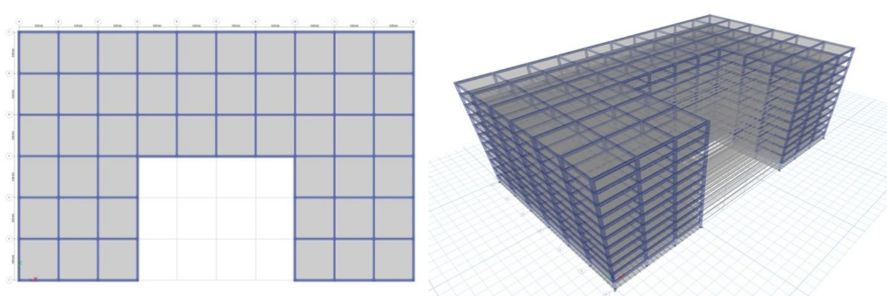

Fig. 3: Model 3: Building with Ribbed Slab a) Plan b) 3D model

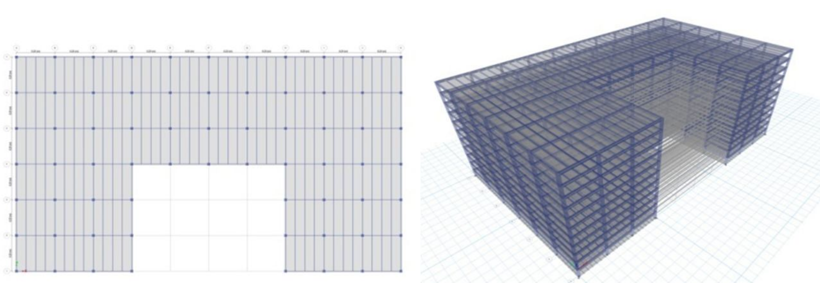

Fig. 4: Model 4: Building with Secondary Beams a) Plan b) 3D model

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IV. RESULTS AND DISCUSSION

Based on the modelling the lists out results are taken from the software analysis of all four models with the concept of horizontal setback approach. The results are as follows:

A. *Storey Displacement*

Deflection of the stories from the initial position is termed as storey displacements and its maximum value is obtained at the top storey. The values of storey displacements in X and Y directions obtained from the analysis has been shown in table and table respectively, while graphical representation is described in fig 5 and fig 6 for X and Y direction respectively. Table 4 and 5 show the storey result in x and y Direction .

Table 4: Storey Displacement in X-Direction (mm)

S.N.	Stories	Model 1	Model 2	Model 3	Model 4
1	G+9	125.641	82.874	67.02	71.603
2	G+8	121.142	80.122	64.596	68.604
3	G+7	113.991	75.47	60.935	64.08
4	G+6	104.35	69.191	56.324	58.361
5	G+5	92.663	61.626	50.974	51.71
6	G+4	79.396	53.086	45.068	44.352
7	G+3	64.977	43.844	38.762	36.486
8	G+2	49.793	34.13	32.192	28.28
9	G+1	34.242	24.143	25.46	19.881
10	G+0	18.947	14.098	18.599	11.477
11	Ground	5.599	4.632	11.082	3.678

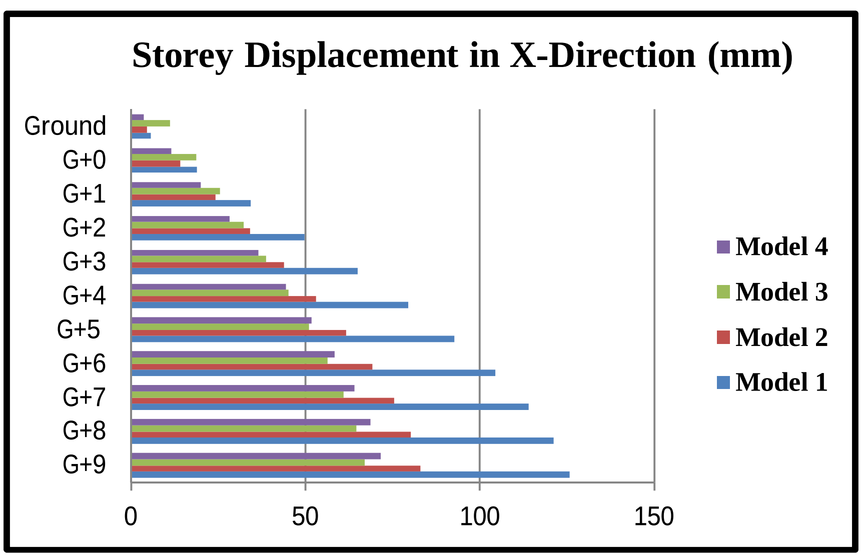

Fig 5: Storey Displacement in X-Direction

Table 5: Storey Displacement in Y-Direction (mm)

S.N.	Stories	Model 1	Model 2	Model 3	Model 4
1	G+9	125.828	83.66	76.382	71.106
2	G+8	121.298	80.82	73.58	68.078
3	G+7	114.115	76.079	69.388	63.552
4	G+6	104.444	69.709	64.099	57.852
5	G+5	92.73	62.053	57.954	51.235
6	G+4	79.439	53.423	51.163	43.929
7	G+3	64.999	44.095	43.909	36.127
8	G+2	49.798	34.303	36.343	27.998
9	G+1	34.236	24.247	28.577	19.688
10	G+0	18.936	14.141	20.612	11.377
11	Ground	5.593	4.636	11.807	3.657

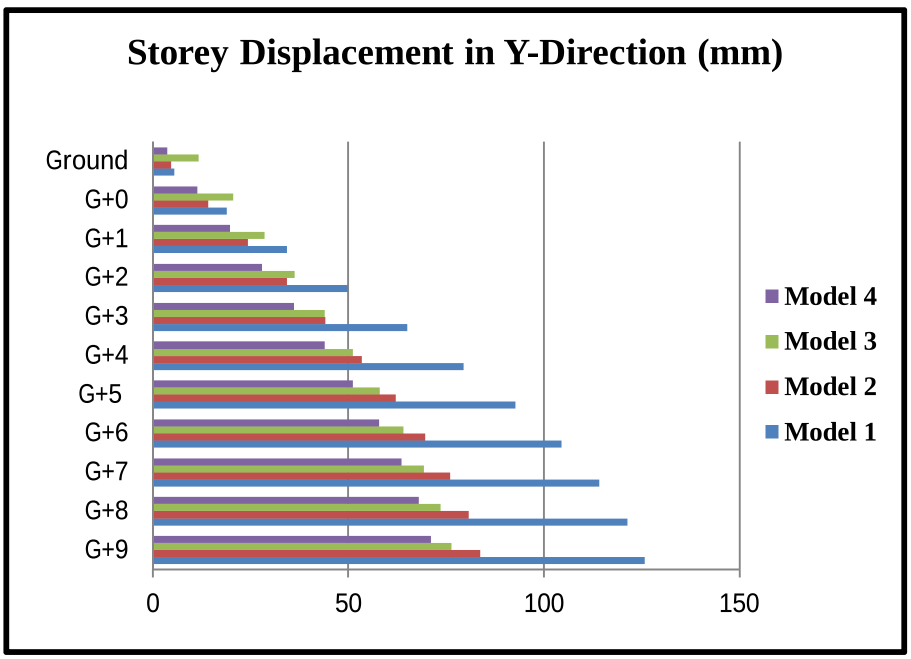

Fig 6: Storey Displacement in Y-Direction

From above representation it is clear that the Storey displacement is nearly equal in both the direction i.e. X and Y for all the models. Model 1 (Building having Flat Slab with Drop Panels) shows higher storey displacement than other models and lowest value of storey displacement has been obtained in Model 3 (Building having Ribbed Slab) and Model 4 (Building having Secondary Beams).

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B. Base Shear and Overturning Moment

Maximum shear force at the base of the structure is termed as base shear. Similarly the moment at the base of the structure is known as overturning moment. Both the quantity depends on the magnitude of lateral forces and dead weight of the structure. Based on the analysis results base shear and overturning moments are shown in table 4.3.

Table 6:Base Shear and Overturning Moment

S.N.	Model	Fx (kN)	Fy (kN)	Mz (kN-m)
1	Model 1	13501.30	13487.39	610205.92
2	Model 2	19132.77	19037.14	864381.30
3	Model 3	13981.33	12339.74	560285.76
4	Model 4	13574.61	13713.20	622647.78

A bar chart representation of base shear and overturning moment is shown in Fig 4.3 and 4.4 respectively.

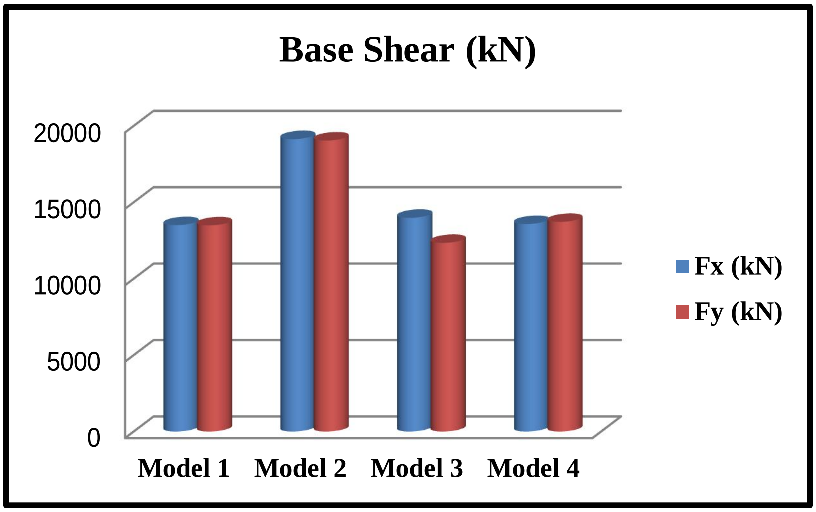

Fig 7: Bar chart comparison of Base Shear

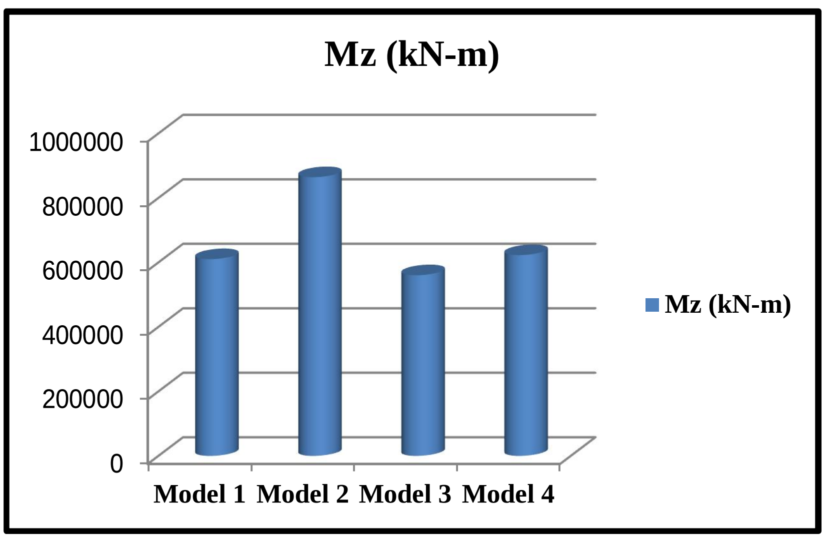

Fig 8: Bar chart comparison of Overturning Moments

Model 2 depicts higher base shear in both the direction as well as overturning moments in Z-direction. Model 1 and Model 3 shows lowest base shear in x-direction and Y-direction respectively.

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C. Storey Acceleration

Storey Acceleration is a dynamic perimeter for the seismic analysis of structures, which shows the acceleration of building under dynamic seismic loading. Table 4.4 shows the value of acceleration for different cases under consideration in this study. Fig 4.5 depicts the bar chart representation of the structures.

Table 4.3: Storey Acceleration (mm/sec2)

S.N.	Model	Acceleration		
		Ux	Uy	Uz
1	Model 1	203.32	460.14	29.10
2	Model 2	299.63	674.16	16.76
3	Model 3	321.03	738.37	18.83
4	Model 4	331.73	738.37	24.46

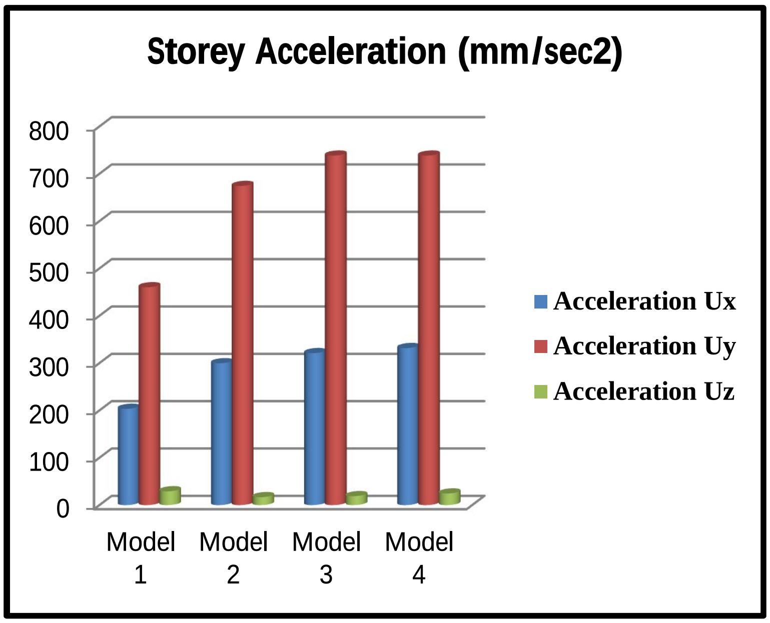

Fig 4.6: Storey Acceleration

Model 4 shows highest value of storey acceleration in all three directions while Model 1 shows lowest value of storey acceleration in X and y direction. In Z direction lowest value has been observed in Model 2.

V. CONCLUSIONS

On The basis of above study on “Seismic Response of Large span slab in Horizontal Setback Building” in which four cases of same storied and height structures has been taken under consideration as defined earlier, following results are concluded.

A. Model 3 and Model 4 i.e. structures having ribbed slab and secondary beams show less storey displacement than other models.
B. Model 1 (Building having Flat Slab with Drop Panels) shows higher magnitude of storey displacement which is nearly 1.7 to 1.8 of Model 3 and Model 4.
C. Base shear and Overturning moments are nearly identical in Model 1 and Model 4 while Model 2 shows highest value of base shear and overturning moment which almost 1.5 times of the Model 1 and model 4.
D. Model 2 shows least storey accelartion amng all four structures while maximum storey acceleration is obtained in Model 4 which is nearly 1.5 to 1.6 of the lowest value.
E. Most preferable long span slab on the basis of this study is Building with Waffle or ribbed Slab.

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