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Behavior of Multi- Storeyed Building for Flat Slab System with and Without Shear Wall under Seismic Loading

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Abstract: ***Multistoreyed buildings are used for both residential and commercial purposes, for commercial usage flat slab systems are adopted over traditional frame structures. This is due to reduced floor to floor height, use of space, easier formwork and shorter construction time. In the present work to improve the performance of the building, A G+12 storey flat slab building with drop and without drop are proposed for the seismic analysis. To resist the lateral loading due to earthquake, different types of shear wall such as concrete and perforated coupled shear walls are used in the structure. Both linear dynamic and non-linear dynamic analysis will be done using the software ETABS and the results will be compared***

Keywords: Flat Slab, Shear Wall, Punching Shear, Storey Drift.

I. INTRODUCTION

Multistoreyed flat slab buildings are generally used for commercial purposes. In a flat slab building the slab are supported by columns without the use of internal beams. The loads are directly transferred from slab to the column. The advantages of applying flat slabs are mainly like depth solution, flat soffit and flexibility in design layout. There are different types of flat slab mainly flat slab without drop, flat slab with drop, flat slab with column head, flat slab with column head and drop. When drop panels are provided it increases the negative moment capacity and shear strength of slabs. Flat slab has got lower stiffness when compared to beam column frame structures which results in larger deflections. Punching failure is the most critical problem when determining the thickness of flat slab. In order to resist lateral loads and to increase stiffness, shear walls are usually provided. Shear walls are the vertical structural member which resist the combination of shear, moment and axial load. These walls are built throughout the height of the building with a thickness of 150 mm to 400 mm.

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The shape and size of shear wall depend upon the geometry and height of building. Non-linear dynamic analysis can be considered as the most accurate method in finding the response of building under seismic loading. Linear dynamic response-spectrum analysis is also useful for better selection of flat slab models.

II. LITERATURE REVIEW

T. M Roberts [1] studied seismic resistance of steel plate shear walls. Shear walls are used to resist lateral loads due to earthquake. 5 continuous H shaped steel shear walls were used. The stiffness decreases with increase size of opening in shear wall.

Fayazuddin et al., [2] studied analysis of flat slab multistoreyed building with and without shear walls under wind loads. The introduction of shear wall resulted in reduction of column moments. The building can be strengthened against lateral loads by providing shear wall.

Rajib et al., [3] compared the performance of 15 storey flat slab building with and without shear wall. Storey drift, storey displacement and storey shear results were compared. Flat slab alone is weak in resisting lateral loads, hence addition of shear wall is necessary.

Kavin and Dipali [4] done a comparative study on steel building with different steel patterns. X type of frame has got less displacement when compared to all other patterns.

Ashwini and Dr. Shivakumara [5] performed pushover analysis for a 10 storeyed flat slab building with and without shear wall. The addition of perimeter beam has got no effect in reducing the displacement of the building.

III. PROBLEM DEFINITION

Flat slab building without drop and with drop are weak in resisting lateral loads. The drift values were also exceeding the limit. Usually the flat slab buildings are weak in resisting lateral loads, hence addition of shear walls in resisting the lateral forces will also be studied. The types of shear wall that will be used in this study will be concrete shear wall and perforated coupled shear wall.

IV. OBJECTIVES

1. Flat slab buildings subjected to seismic analysis.
2. Influence of different shear walls on the building.
3. Linear (RESPONSE SPECTRUM ANALYSIS) and non-linear dynamic(TIME HISTORY) analysis on the building.

4. Storey drift, storey displacement, storey shear and punching shear results.

V. MODELLING AND ANALYSIS

A G+12 storey building is taken for seismic analysis. The flat slab building consists of 9 bays in both X and Y direction with a bay width of 8m in X and Y direction. Both linear and non-linear dynamic analysis will be done. The six flat slab buildings are

1. Model 1 – Flat slab without drop
2. Model 2 – Flat slab with drop
3. Model 3 – Flat slab without drop with concrete shear wall
4. Model 4 – Flat slab without drop with perforated coupled shear wall
5. Model 5 - Flat slab with drop with concrete shear wall
6. Model 6 – Flat slab with drop with perforated coupled shear wall. Specifications of flat slab without drop

Type of building	Commercial
No. of storey	G+12
Height of storey	3 m
Grade of concrete	M30
Grade of steel	HYSD 415
Live load	3 kN/m^2
Floor finish	1 kN/m^2
Wall load	1.25 kN/m^2
Size of perimeter beam	500 X 750 mm
Size of column	800 X 800 mm
Thickness of slab	250 mm

Specification of flat slab with drop

Type of building	Commercial
No. of storey	G+12
Height of storey	3 m
Grade of concrete	M30
Grade of steel	HYSD 415
Live load	3 kN/m^2
Floor finish	1 kN/m^2
Wall load	1.25 kN/m^2
Size of perimeter beam	450 X 700 mm
Size of column	750 X 750 mm
Thickness of slab	250 mm
Thickness of drop	350 mm
Size of interior drop	3000 X 3000 mm
Size of exterior drop	1875 X 3000 mm
Size of corner drop	1875 X 1875 mm

These are the basic specification of both buildings. In to these buildings two types of shear walls are also added.

- Concrete shear wall.
- Perforated coupled shear wall.

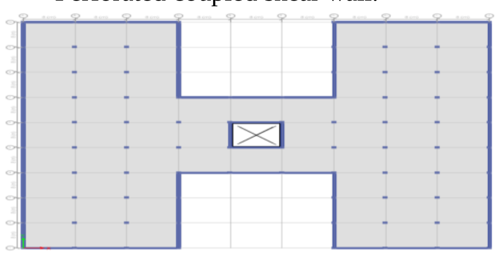

Fig 1: Typical floor plan for G+12 storey flat slab building without drop

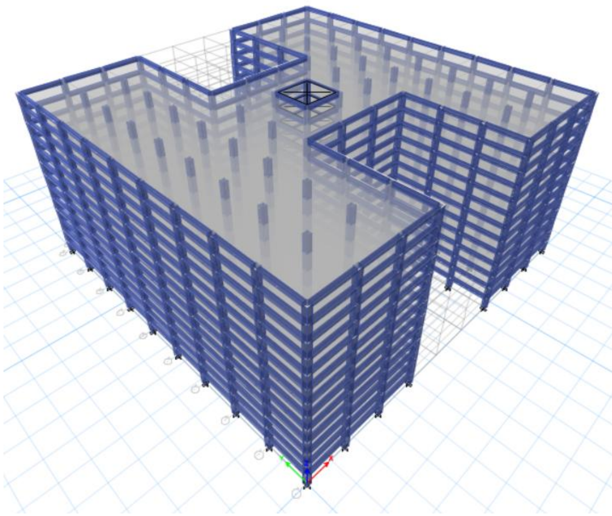

Fig 2 : 3D model for G+12 storey flat slat building without drop

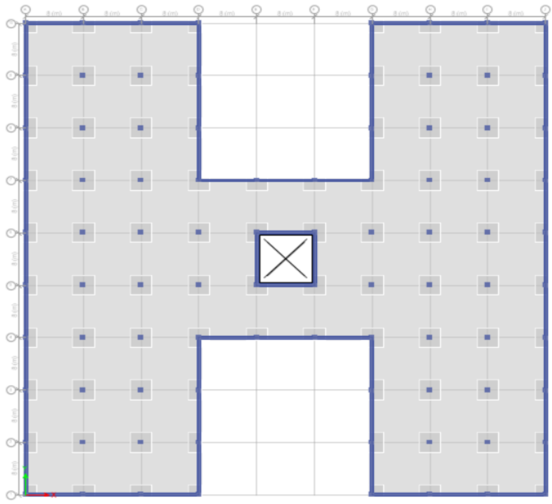

Fig 3 : Typical floor plan for G+12 storey flat slab building with drop

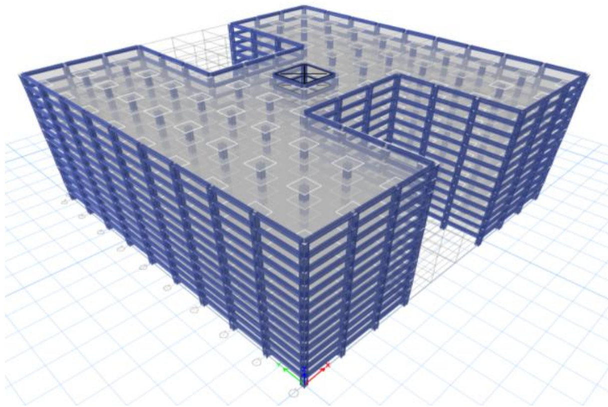

Fig 4 : 3D model for flat slab building with drop

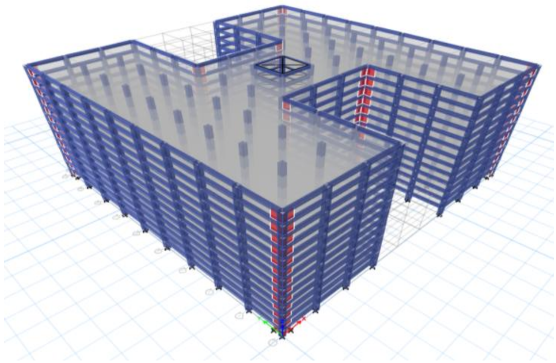

Fig 3 : 3D model for flat slab without drop with 250 mm concrete shear wall

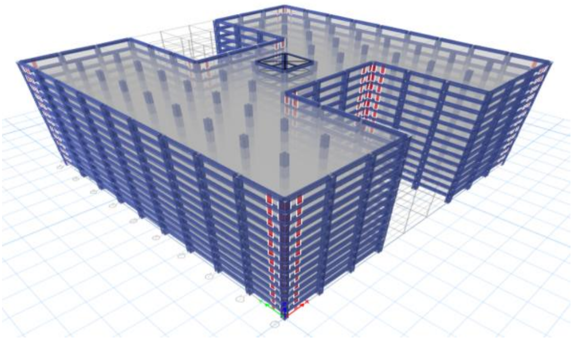

Fig 4 : 3D model for flat slab without drop with 250 mm perforated coupled shear wall

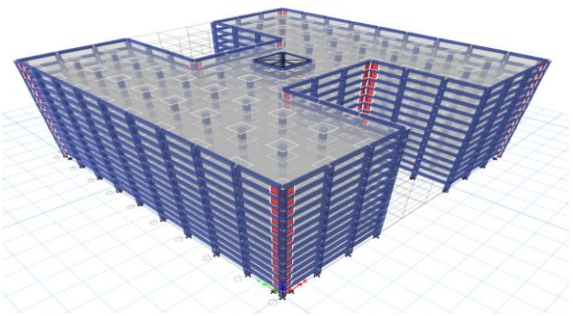

Fig 5: 3D model for flat slab with drop with 200 mm concrete shear wall

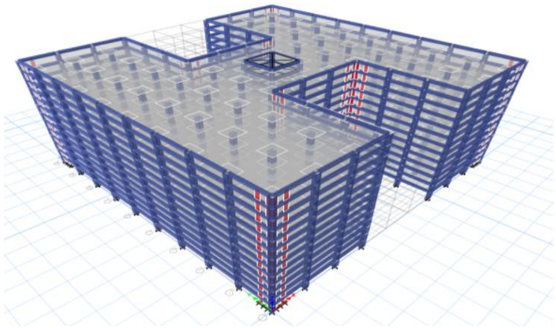

Fig 6 : 3D model for flat slab with drop with 200 mm perforated coupled shear wall

Shear wall of 250 mm is provided at corners in flat slab without drop at 2 m length and 200 mm in flat slab with drop. Perforated coupled shear wall of length 1 m is provided at the corners, each separated by 1 m. Linear and non-linear dynamic analysis will be done on all the models and their response shall be studied and the results will be compared.

VI. RESULTS AND DISCUSSIONS

RESPONSE SPECTRUM ANALYSIS

Linear dynamic response spectrum analysis were done for all the models. Maximum storey drift, maximum storey displacement, storey shear, punching shear values were obtained. For a flat slab building the drift value should be less than 0.001 from IS 1893 (Part 1) : 2016

a) Maximum storey drift

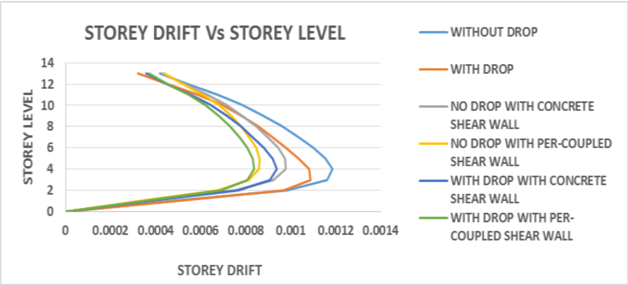

Fig 7 : Drift along X direction

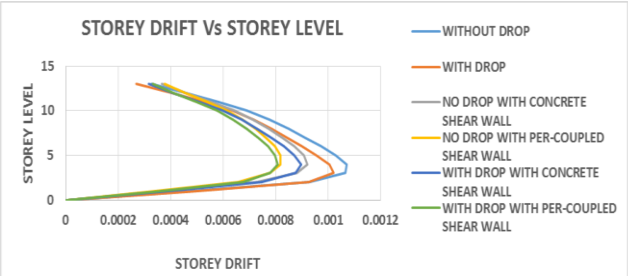

Fig 8 : Drift along Y direction

Table 3 : Max drift values

Description	Drift	
	X	Y
MODEL 1	0.001187	0.001071
MODEL 2	0.00108	0.001021
MODEL 3	0.000979	0.000922
MODEL 4	0.000863	0.00082
MODEL 5	0.000938	0.000897
MODEL 6	0.000838	0.000809

Hence from the above results it is clear that for flat slab without drop and with drop the drift value exceeded the permissible limit. The drift were more in X direction compared to Y direction. The drift value is least for flat slab with drop with perforated coupled shear wall.

b) Maximum storey displacement

From the results it is clear that all the buildings were safe in deflection. The deflection is higher for flat slab without drop. The deflection is least for flat slab with drop with perforated coupled shear wall. The displacement values were higher in X direction compared to Y direction. For this flat slab buildings the displacement values should be less than 39 mm.

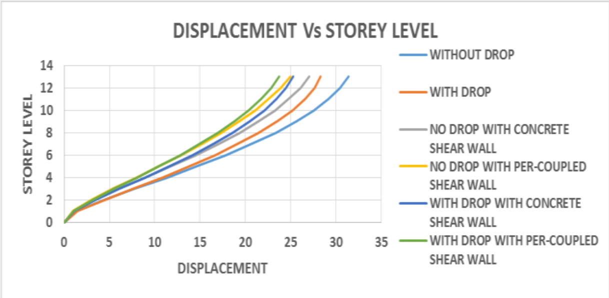

Fig 9 : Displacement along X direction

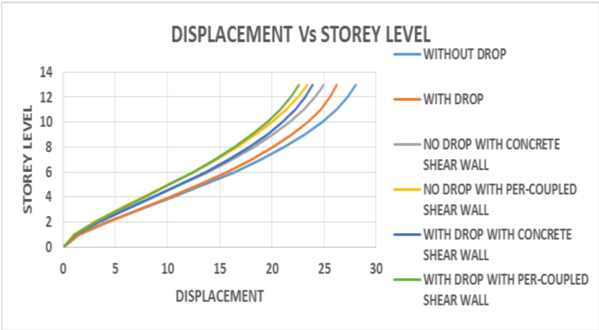

Fig 10 : Displacement along Y direction

Table 4 : Maximum displacement values

Description	Displacement (mm)	
	X	Y
MODEL 1	31.37	28.00
MODEL 2	28.32	26.21
MODEL 3	27.08	24.98
MODEL 4	24.95	23.98
MODEL 5	25.31	23.92
MODEL 6	23.72	23.60

c) Storey shear

The storey shear is maximum for flat slab with drop with perforated coupled shear wall in X direction and flat slab without drop with perforated coupled shear wall in Y direction.

Table 5 : Storey shear values

Description	Storey shear (kN)	
	X	Y
MODEL 1	9503	10755
MODEL 2	10185	11040
MODEL 3	10998	12210
MODEL 4	12142	13197
MODEL 5	11444	12268
MODEL 6	12329	13066

d) Punching shear

Punching shear is obtained by demand by capacity ratio. For a flat slab building to be safe under punching the demand by capacity ratio should be less than 1. Punching shear obtained for all the buildings were less than 1, hence safe.

Time History Analysis

EL-CENTRO time histroy datas were used for non-linear dynamic analysis. In time histroy analysis the actual recorded earthquake force is directly applied to the mathematical model.

a) Maximum storey drift

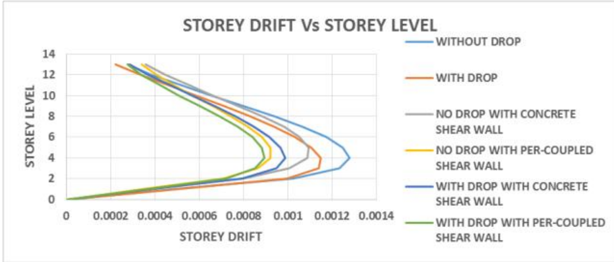

Fig 11 : Drift along X direction

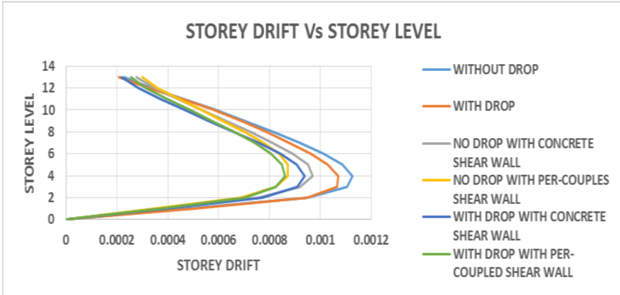

Fig 12 : Drift along Y direction

Table 6 : Maximum storey drift

Description	Drift	
	X	Y
MODEL 1	0.001281	0.001128
MODEL 2	0.001151	0.001071
MODEL 3	0.001095	0.00097
MODEL 4	0.000921	0.000874
MODEL 5	0.000988	0.000939
MODEL 6	0.000894	0.000862

For flat slab building the drift value should be less than 0.001. When non-linear dynamic analysis was done, the drift values exceeded for flat slab without drop and flat slab with drop in both X and Y direction and flat slab without drop with concrete shear wall in X direction. The drift values were least for flat slab with drop with perforated coupled shear wall.

b) Maximum storey displacement

The displacement values were taken with respect to time.The displacement was maximum for flat slat without drop in both X and Y direction. The displacement were least for flat slab with drop with perforated coupled shear wall. For this flat slab buildings the displacement should be less than 39 mm.

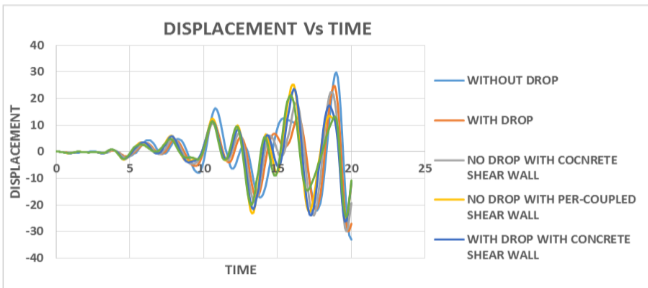

Fig 13 : Displacement Vs Time along X direction

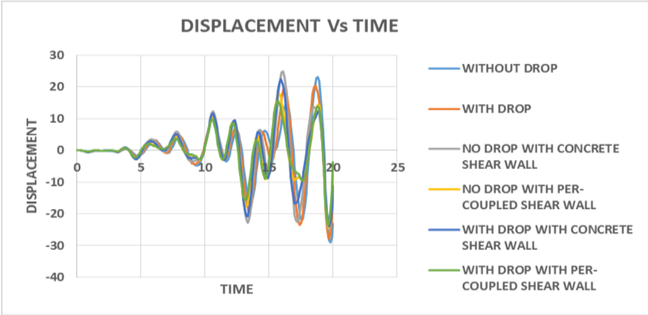

Fig 14 : Displacement Vs Time along Y direction

Table 7 : Maximum displacement values

	Time(Sec)	X (mm)	Time(Sec)	Y (mm)
Model 1	20	33.11	19.8	29.12
Model 2	19.8	30	19.7	28.02
Model 3	19.7	29.97	19.7	25.08
Model 4	19.7	25.57	19.7	24.30
Model 5	19.6	26.34	19.7	23.95
Model 6	19.7	24.422	19.6	23.40

c) Storey shear

The storey shear is minimum for flat slat without drop and is maximum for flat slab with drop with perforated coupled shear wall.

Table 8 : Storey shear values

	TIME	X (kN)	TIME	Y (kN)
MODEL 1	20	9509	19.8	10720
MODEL 2	19.9	10191	19.7	11042
MODEL 3	19.7	11227	19.7	12373
MODEL 4	19.7	12334	19.7	13335
MODEL 5	19.7	11608	19.7	12376
MODEL 6	19.7	12551	19.6	13265

d) Punching shear

Punching shear is obtained by demand by capacity ratio. For a flat slab building to be safe under punching the demand by capacity ratio should be less than 1. Punching shear obtained for all the buildings were less than 1, hence safe.

VII. CONCLUSION

A G+12 storey flat slab buildings were modelled and both linear and non-linear dynamic analysis were done using the software Etabs. When time history analysis was done the displacement, drift and base shear value got increased when compared to response spectrum analysis.

Perforated coupled shear wall provided in flat slab with drop is the most suitable model in resisting the seismic forces, when compared with other models.

This model has got less drift about 30 % less compared to flat slab without drop.

Displacement and storey shear is also less for flat slab with drop with perforated coupled shear wall, when compared to all other models.

All the buildings were safe in punching shear.

Since the column, beam and shear wall size can be reduced when Perforated coupled shear wall provided in flat slab with drop is adopted, which makes the building economical

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