COMPARATIVE STUDY OF MULTISTORIED COMMERCIAL BUILDING WITH FLAT SLAB

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Abstract : In present era, conventional reinforced concrete (RC) frame buildings are commonly used for the construction. The use of flat slab building provides many advantages over conventional RC frame building in terms of architectural flexibility, use of space, easier formwork and shorter construction time.in the present work conventional and flat slab G+3 story building is considered for cost comparison. The building is considered to be situated in earthquake zone2. The dead load, wind load and live load are considered as per Indian codes 875-1987.The design is carried out using IS456-2000 and for reinforcement detailing SP 34 is used.

Key words **– RC Frame, Flat Slab, Cost comparision, Etabs.**

I. INTRODUCTION

1.1. FLAT SLAB

Common practice of design and construction is to support the slabs by beams and support the beams by columns. This may be called as beam-slab construction. The beams reduce the available net clear ceiling height. Hence in warehouses, offices and public halls sometimes beams are avoided and slabs are directly supported by columns. These types of construction are aesthetically appealing also. Flat slabs which are directly supported by columns.

The reinforced concrete frame buildings are commonly used in construction. Flat slabs are one of the most popular floor systems used in residential buildings, car parks and many other structures. Flat slab are favoured by both architects and clients because of their aesthetic appeal and economic purpose. The flat slab system is a special structural form of reinforced concrete construction that possesses major advantages over the conventional beam column frame. The flat slab system provides easier formwork, architectural flexibility, unobstructed space, lower building height and shorter construction time.

A flat slab floor system is often the choice when it comes to heavier loads such as multi-storey car parking, libraries and multi-storey buildings where larger spans of free space are also required. Common practice of design and construction is like to support the slabs by beams and next support the beams by columns. This may called as beam slab construction. In normal frame construction uses columns, slabs and beams, however it ought to be potential to undertake construction without using beams, in this case the frame system would comprises of slab and column without beams. These types of buildings are called as flat slabs. The slab directly rests on column and load from the slab is directly transferred to the columns and then to be foundation. Figures shows typical flat slab used for construction.

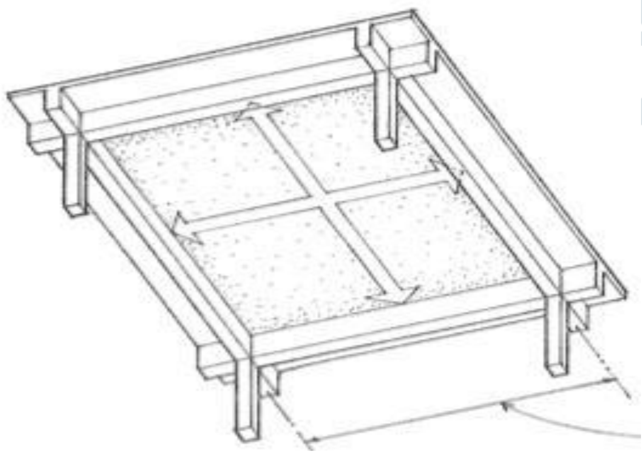


Fig. 1: Typical Conventional Slab

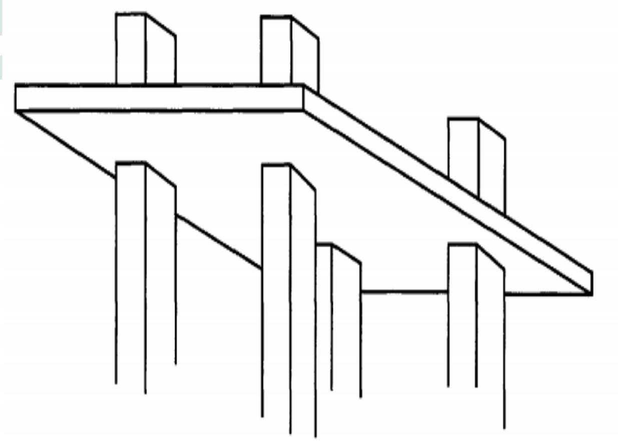


Fig. 2: Typical Flat Slab

Fig. 3 : Flat Slab without Drop

Fig. 4: Flat Slab with Drop

1.2 Elements of Flat Slab:

Figures show the elements and reinforcement in flat slabs with and without drops.

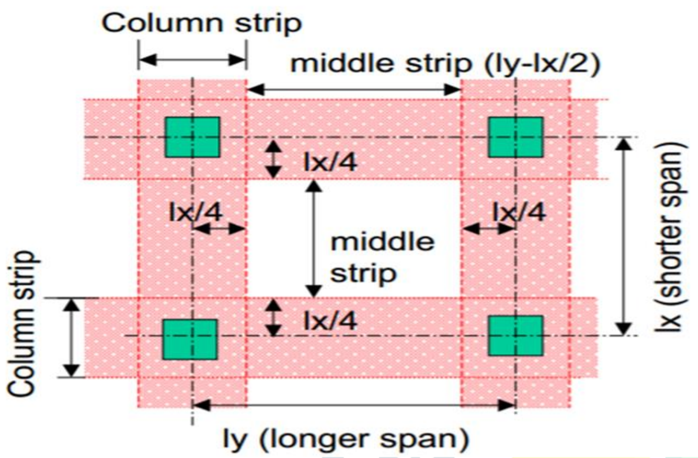


Fig. 5: Elements of Flat Slab without Drop

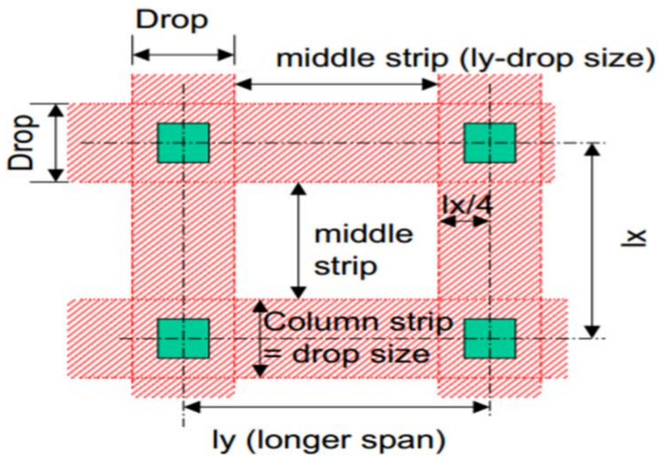


Fig. 6: Elements of Flat Slab with Drop

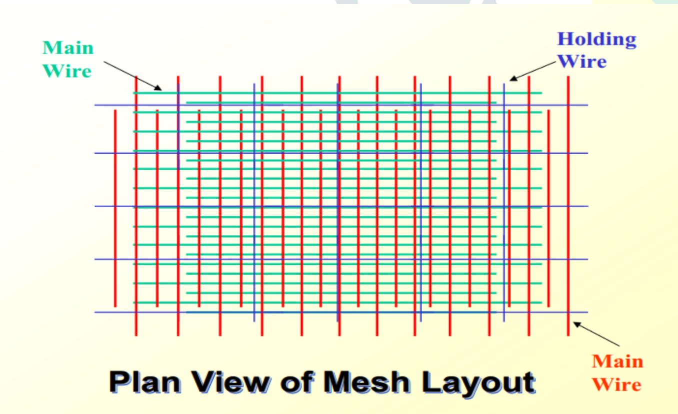


Fig. 7: Plan View of Mesh Layout

Fig. 8: Reinforcement in Flat Slab

II ANALYSIS AND DESIGN OF COMMERCIAL BUILDING

The following are the different types of structures considered for multistoreyed commercial building.

Model 1: 4 x 4 Bays, G+3 Conventional Building
Model 2: 4 x 4 Bays, G+3 Flat Slab Building without Drop panel
Model 3: 4 x 4 Bays, G+3 Flat Slab Building with Drop panel

For analysis, different softwares are available during these days. "CSI-ETABS V-15" integrated building software is used for analysis of frames. Manual analysis and design using IS456:2000 carried out for the slabs and foundations with the help of created excel-templates made accordingly. Figures show the models considered for different cases.

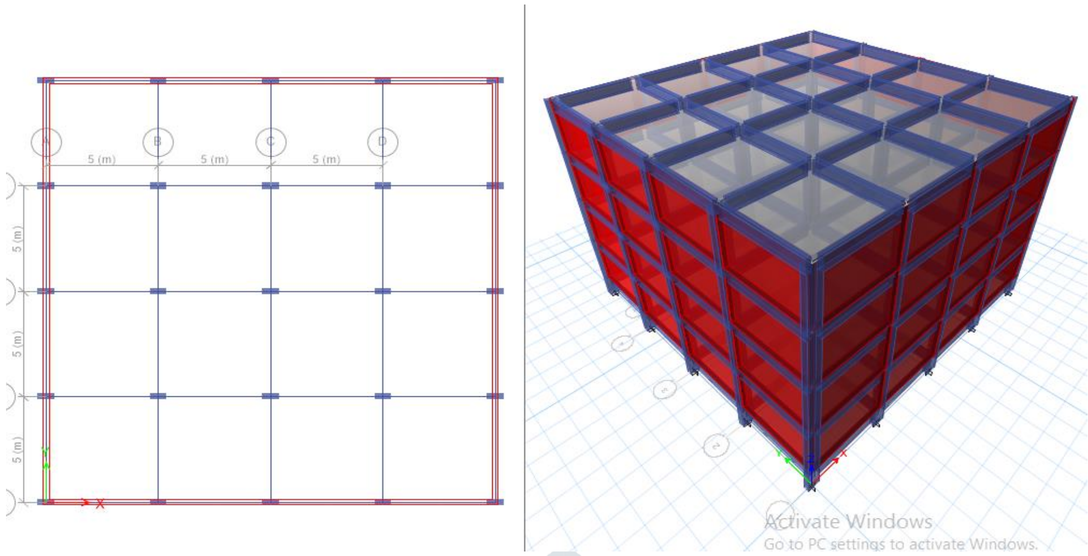


Fig 9 : Model 1 - Conventional Building

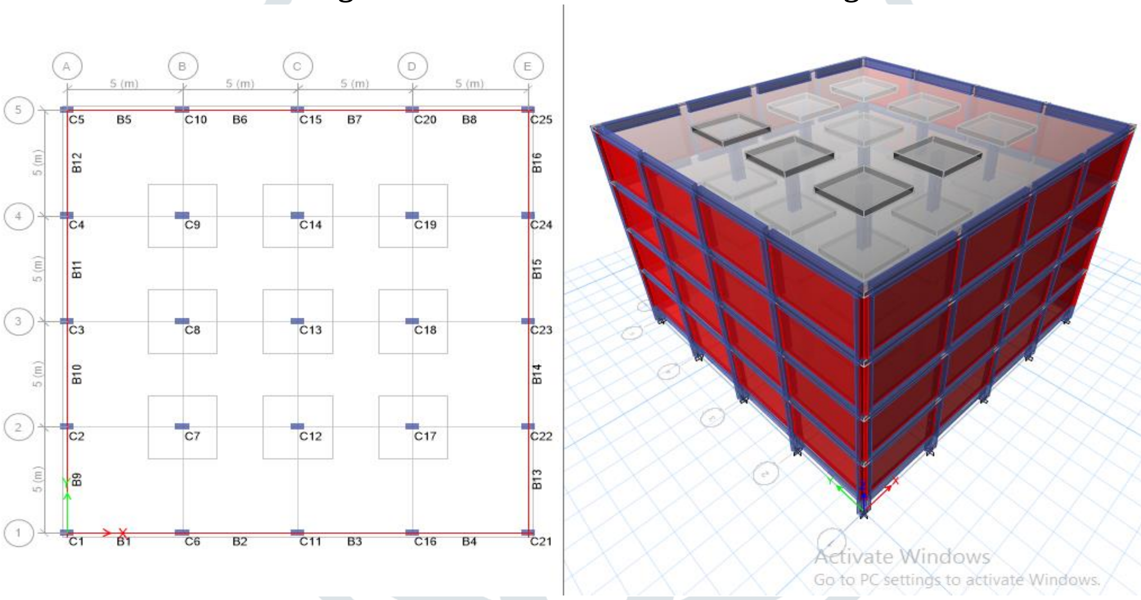


Fig 10 : Model 2 - Flat Slab without Drop

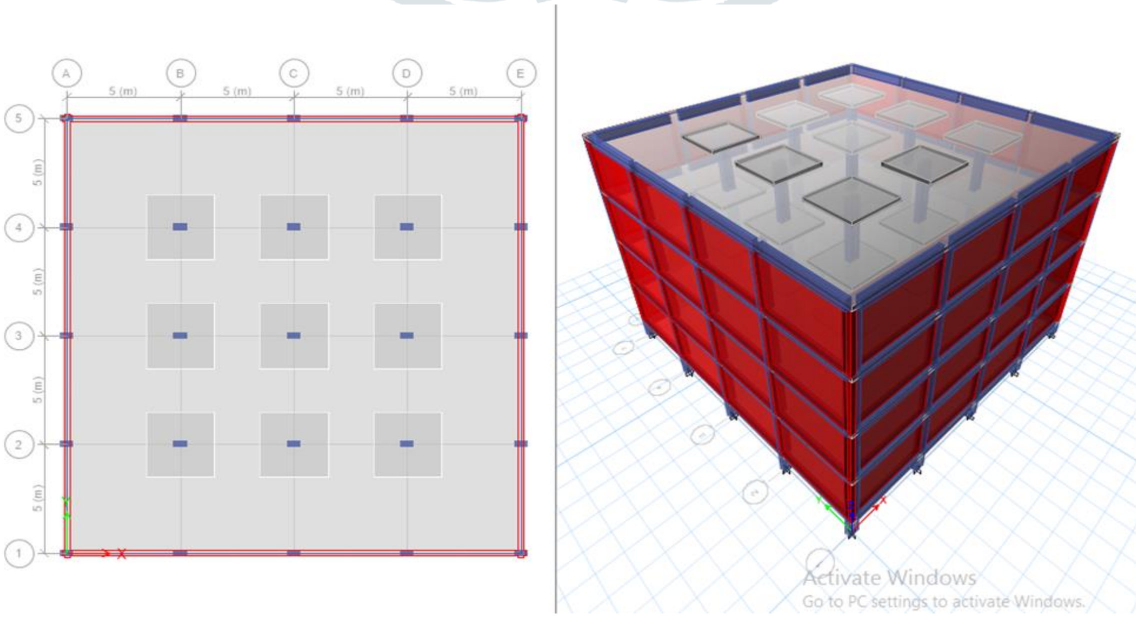


Fig 11 : Model 3 - Flat Slab with Drop

III. LOADS AND LOAD COMBINATIONS

3.1 Loading on Structure:

The load considered for the Study is mentioned below which are in accordance with IS 1893(Part 1):2002.

1) Dead load

i. The self-weight of the structural members is calculated according to the codal provisions and taken care in the software.

ii. Dead load on floor finishing: 1.5 kN/m2

2) Live Load

i. Live load on Floor: 4 kN/m2

ii. Live load on Roof: 4 kN/m2

3) Seismic Load

i. Seismic Zone: Zone-II (As per IS 1893(Part-1): 2002

ii. Type of Structure: Ordinary RC Moment Resisting Frame IS 1893(Part1): 2002.

iii. Damping ratio: 5% for RC frame structure.

iv. Seismic zone factor (Z): 0.16 (Table 2 of IS 1893(Part-1): 2002.

v. Importance factor (I): 1 (Table 6 of IS 1893(Part-1): 2002.

vi. Response reduction factor (R): 5.0 (Table 7 of IS 1893(Part-1): 2002.

vii. Fundamental natural period: (0.075 $h^{0.75}$) for RC frame building of vibration (Ta) As per IS 1893(Part-1): 2002.

viii. Foundation soil type: Type-1(Hard Soil), Type-2(Medium Soil), and Type-3(Soft Soil) (As per IS 1893(Part-1):2002.

3.2 Load Combinations:

Load combinations for all models are considered as per the codal provisions of IS 1893(Part 1):2002 and IS 456:2000.

3.3 Geometrical Considerations:

Following dimensions of the elements are considered while analyzing the structure.

1. Size of Building – 20 m X 20m
2. Size of Panel – 5 m X 5m
3. Size of Column – 300 mm x 600 mm
4. Size of Beam – 230 mm x 600 mm
5. Thickness of Slab – 250 mm
6. Concrete Grade – M20
7. Grade of Steel – Fe 415
8. Concrete Mix – RMC
9. Live Load – 4 kN/m^2
10. Seismic Zone – II
11. Location – Solapur
12. Strip Dimensions

Table 1: Strip Dimensions

Longer Span	Shorter Span
L1=5 , L2=5 Column Strip=0.25L2=1.25 But not greater than 0.25L2=1.25 Middle Strip=2.5	L1=5 , L2=5 Column Strip=0.25L2=1.25 But not greater than 0.25L2=1.25 Middle Strip=2.5

13. Drop Dimensions: Drop of size 3.0m X 3.0m i.e. in column strip width.

Table 1: Drop Dimensions

Longer Span	Shorter Span
L1=5 , L2=5m Not less than L1/3=1.667m	L1=5 , L2=5m Not less than L1/3=1.667m

IV RESULTS AND DISCUSSIONS

4.1 Reinforcement Details in Flat Slab

Table shows reinforcement details in a Flat slab without drop. The reinforcements are placed in middle strip and column strip. The reinforcement required is less in middle strip as compared column strip.

Table 4.3.: Reinforcement Details in Flat Slab

	Column Strip		Middle Strip	
Exterior Panel	Positive R/F	Negative R/F	Positive R/F	Negative R/F
	ϕ10mm@175mm c/c	ϕ12mm@100mm c/c	ϕ10mm@275mm c/c	ϕ10mm@275mm c/c
	Column Strip		Middle Strip	
Interior Panel	Positive R/F	Negative R/F	Positive R/F	Negative R/F
	ϕ12mm@225mm c/c	ϕ16mm@150mm c/c	ϕ10mm@250mm c/c	ϕ10mm@200mm c/c

4.2 Base Shear:

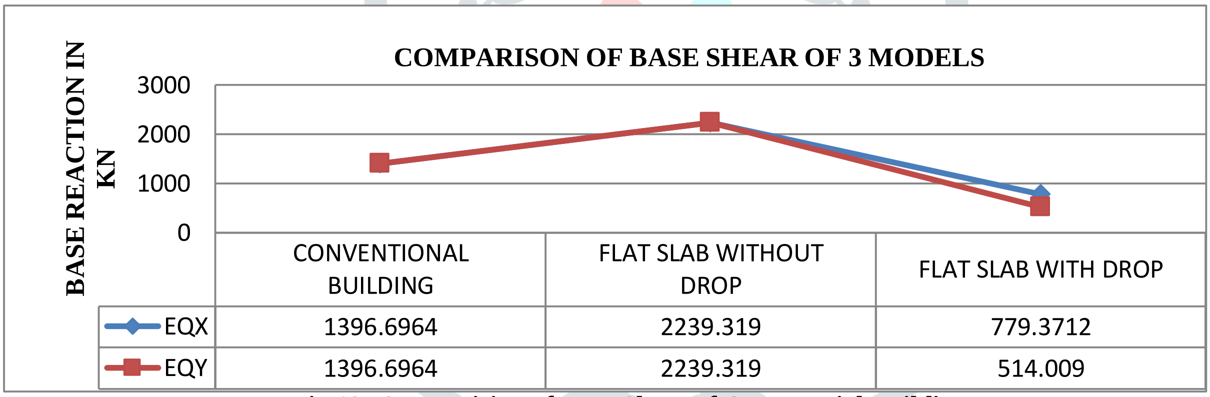


Fig 12: Comparision of Base Shear of Commercial Building

4.3 Base Moments:

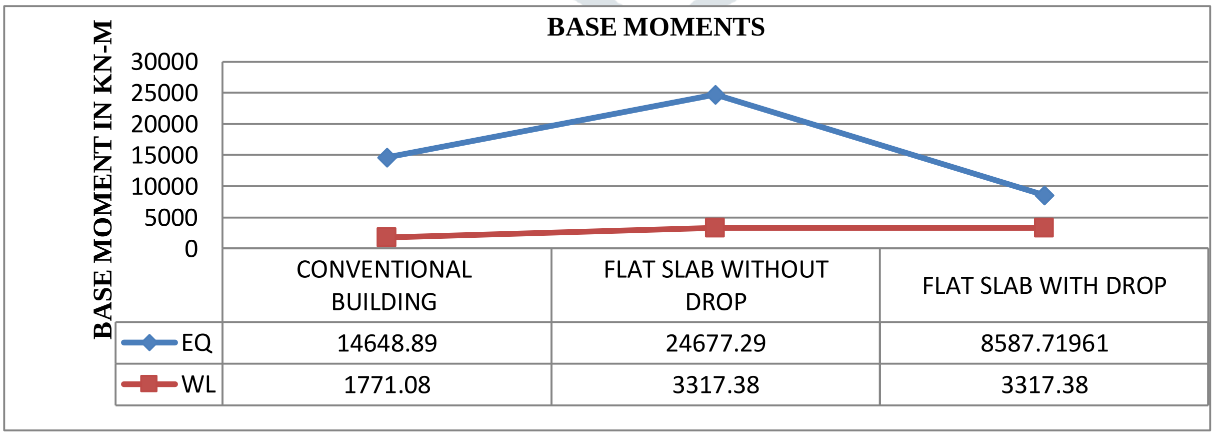
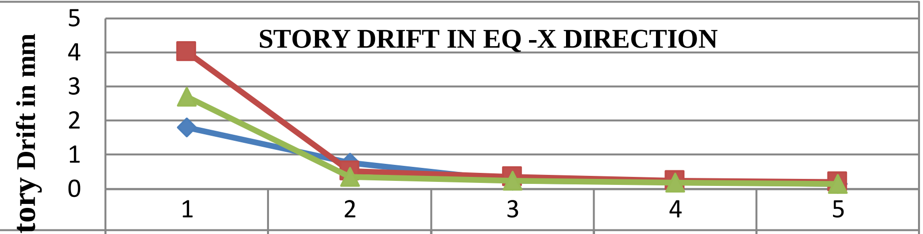


Fig 13: Comparision of Base Moment of Commercial Building

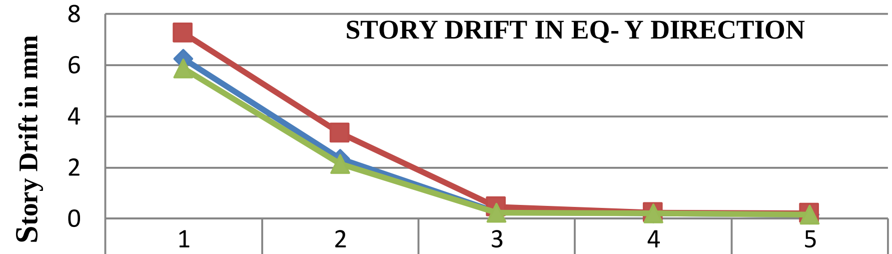
4.4 Story Drift in X-Direction:



	1	2	3	4	5
CONVENTIONAL BUILDING	1.79	0.77	0.24	0.2	0.15
FLAT SLAB WITHOUT DROP	4.02	0.52	0.34	0.24	0.2
FLAT SLAB WITH DROP	2.7	0.35	0.23	0.18	0.14

Fig. 14: Comparision of Story Drift in X Direction

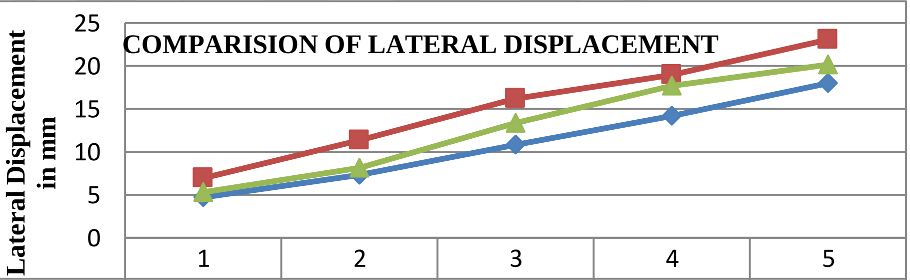
4.5 Story Drift in Y-Direction:



	1	2	3	4	5
CONVENTIONAL BUILDING	6.25	2.35	0.26	0.2	0.17
FLAT SLAB WITHOUT DROP	7.25	3.34	0.46	0.24	0.21
FLAT SLAB WITH DROP	5.87	2.15	0.23	0.2	0.15

Fig. 15: Comparision of Story Drift in Y Direction

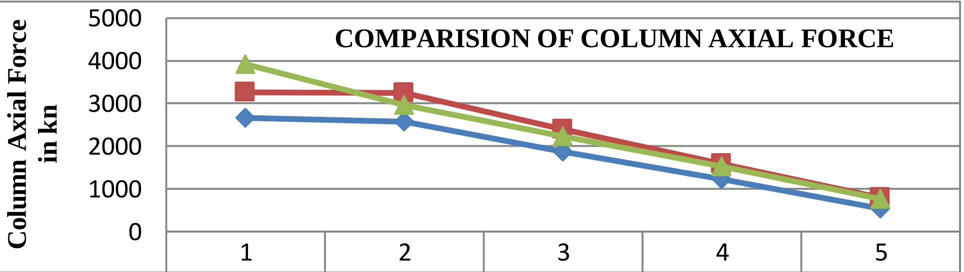
4.6 Lateral Displacement:



	1	2	3	4	5
CONVENTIONAL BUILDING	4.76	7.35	10.82	14.23	18.05
FLAT SLAB WITHOUT DROP	6.97	11.4	16.21	18.96	23.12
FLAT SLAB WITH DROP	5.3	8.2	13.4	17.7	20.2

Fig 16: Comparision of Lateral Displacement

4.7 Column Axial Force:



	1	2	3	4	5
CONVENTIONAL	2658.6689	2577.58	1863.83	1232.38	533.3436
FLAT SLAB WITH DROP	3262.3882	3243.134	2394.56	1586.3121	802.2139
FLAT SLAB WITHOUT DROP	3925.17	2966.312	2227.3168	1520.48	758.42

Fig 17: Comparision of Axial Force in Column

Figures 12 to 17 show the comparision of base shear, base moments, storey drifts, lateral displacements and axial forces in columns for all three models of structures with conventional slabs and flat slabs.

4.8 Comparison of Concrete Quantity:

Table 3: Concrete Quantity in m^3

	CONCRETE QUANTITY (m^3)		
TYPE OF MODEL	BEAM	COLUMN	SLAB
CONVENTIONAL BUILDING	146.625	70.2125	255.68
FLAT SLAB WITHOUT DROP	123.165	56.25	319.6
FLAT SLAB WITH DROP	123.165	56.25	368.2

4.8 Comparison of Steel Quantity:

Table 4: Steel Quantity in Tonnes

	STEEL QUANTITY IN (TONNES)		
TYPE OF MODEL	BEAM	COLUMN	SLAB
CONVENTIONAL BUILDING	23.978	17.774	3.9763
FLAT SLAB WITHOUT DROP	8.09	12.832	9.4159
FLAT SLAB WITH DROP	8.0782	12.832	10.223

4.9 Total Quantity Of Steel And Concrete For 3 Models

Table 5: Total Steel & Concrete Quantity of Commercial Building

TYPE OF MODEL	STEEL QTY.(TON)	CONCRETE QTY.(m3)
CONVENTIONAL BUILDING	45.728	216.938
FLAT SLAB WITHOUT DROP	30.338	179.415
FLAT SLAB WITH DROP	31.133	228.015

Table 3 to 5 show the concrete quantity, steel quantity and total quantity of steel and concrete required for all three types of structure considered for the design of commercial building.

V CONCLUSIONS:

- The quantities of steel and concrete are less for Flat slab structure than Conventional structure.
- The steel quantity for flat slabs is 25% less as compare to conventional building whereas concrete quantity for flat slab without drop is 17% less but 5% more for flat slab with drop as compare to conventional building.
- Base shear, base moments and story drifts are less for flat slab with drop as compared to conventional structures.
- Lateral displacements and axial forces in column are more for flat slab structures.
- Weight of Flat slab structure is quite low as compared to conventional slab structure.
- Flat slab structure is more economical than that of conventional slab structure.
- Flat slab structures are the best solution for high rise structure as compared to conventional slab structure.

VI REFERENCES

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