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Analysis & Design Of High-Rise Building For Different Configuration Subjected To Seismic & Wind Loading And Its Comparative Analysis Using Etabs.

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Abstract

This Project focuses on the analysis and design of G+30 RCC multistorey building with two geometric configuration- rectangular & L-shaped building using Etabs. ETABS stands for Extended Three-Dimensional Analysis of Building Structures. Etabs is generally used to analyse various structures like sky scrapers, Rcc & steel building both low- and high-rise buildings.

The primary objective is to evaluate the structural performance of different layouts when subjective to both wind load as well as seismic loads and to perform a comparative analysis based on key response parameters.

Keywords

Etabs, High-rise building, different plan configuration, deformation, structural Analysis.

Introduction

The structural behaviour of multistorey buildings significantly depends on their geometric configurations, particularly in regions susceptible to laterals loads such as wind & earthquakes. With the growing complexities of architectural forms & increasing demand for taller structures, engineers are often faced with the challenge of ensuring both aesthetic appeal & structural safety. In structural engineering, the seismic performance & cost effectiveness of multi-storey buildings are two critical factors that influence design decisions.

This project aims to analyse & design G+30 storey building having same zone, importance factor, soil type, reduction factor and loading with varying geometric configurations such as rectangular & L-shaped layouts in Etabs. Etabs provides a comprehensive platform for modelling, analysing & designing high-rise structures under seismic & wind loading conditions, adhering to the latest IS codes & standards.

By Comparing structural responses of both building, SF & BM, Storey Displacement, base shear, lateral displacement and inter- storey drift are computed and then compared. The Objective is to understand the performance of different structural layouts under seismic and wind loading in order to aim in selecting designs for safety, stability and also the most economical in terms of material usage & structural efficiency. The Ultimate goal is to provide

Guidance on optimal geometric planning that ensures safety, code compliance and cost minimization.

Modelling of RCC frames

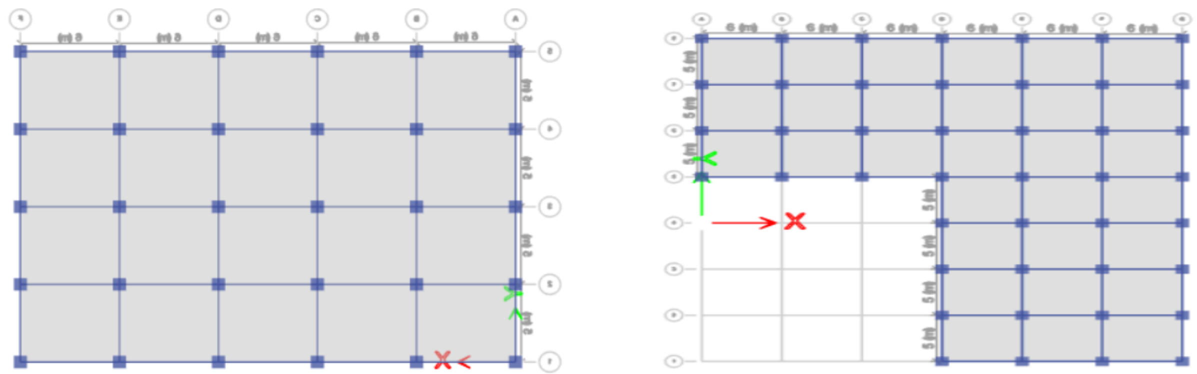
RCC frames structures represents the structures geometric & structural characteristics. The process typically involves defining the geometry of beams, columns & slabs, assigning material properties, specifying support conditions & applying all the loads. This allows for analysis of building behaviour under different loads & conditions such as wind & seismic forces. The load is transferred from the slab to the beam, from the beam to the columns, and then from the columns to the foundation, which ultimately distributes the load to the soil.

In this study we have adopted 2 cases by assigning different layouts for same type of structures, as explained below:

- Rectangular Building.
- L-Shaped building.

The RCC building is of 30m x 20m in plan for rectangular building & 36m x 35m in plan for L-shaped building, having column spaced at 5m from centre to centre. A floor-to-floor height of 3.3m is assumed, making total height of building102.3m.

2D Plan of the both building are show in the following figure:



(a) (b)

Fig 1: Plan (a) Rectangular (b) L-Shape

TABLE-1

Building Description		
Shape	Rectangular	L-Shaped
Size of building	30mx 20m	36m x 35m
No. of Storey	30	30
Storey Height	3.3m	3.3m
Beam Gf to 10^{th} storeys Dimension	600mmx600mm	600mmx600mm
Beam 11^{th} to 30^{th} storeys Dimension	400mmx600mm	400mmx600mm
Column Gf to 10^{th} storey Dimension	1000mmx1000mm	1000mmx1000mm
Column 11^{th} to 20^{th} storey Dimension	800mmx800mm	800mmx800mm
Column 21^{st} to 30^{th} storey Dimension	600mmx800mm	600mmx800mm
Slab Thickness	150mm	150mm
Thickness of main wall	230mm	230mm
Thickness of inner wall	115mm	115mm
Height of parapet wall	1m	1m
Thickness of parapet wall	230mm	230mm
Support condition	Fixed	Fixed

I.Material Specification

TABLE-2

Material Specification	
Grade of Concrete, Fck	35N/mm2
Grade of steel, Fy	500N/mm2
Density of Concrete	25KN/mm2
Density of Brick	20KN/m3

II.Loading

Loads that act on structure are Dead Load (DL), Live Load (LL), Wind Load (WL) & Earthquake Load (EL).

1. Seismic Load: Seismic zone- IV (0.24), Importance factor- 1, Response reduction factor – 5, Soil Type-II, Damping- 5%. (As per IS 1893:2016)
2. Self-weight comprises of weight of beams, columns & slab of the buildings.
3. Dead Load comprises of self-weight, floor finish, wall load and live load of the building.

- Load calculation of 230mm brick wall= (thickness of wall x (height of wall-beam depth) x brick density)

  = 0.23m x (3.3m-0.6m) x 20KN/m3
  = 12.42KN/m2.
- Load calculation of 115mm brick wall= (thickness of wall x (height of wall-beam depth) x brick density)

  = 0.115m x (3.3m-0.6m) x20KN/m3
  = 6.21KN/m2.
- Load calculation of parapet wall at top = (thickness of wall x height of wall x brick density)

  =0.23mx1mx20KN/m3
  = 2.07KN/m2.

4. Live Load of 3KN\m2 floor load, 1.5KN/m2 roof load as per (IS 875: 1987 part 2.) is considered
5. Wind Load- As per IS 875:2015 Part 3 wind load is considered.

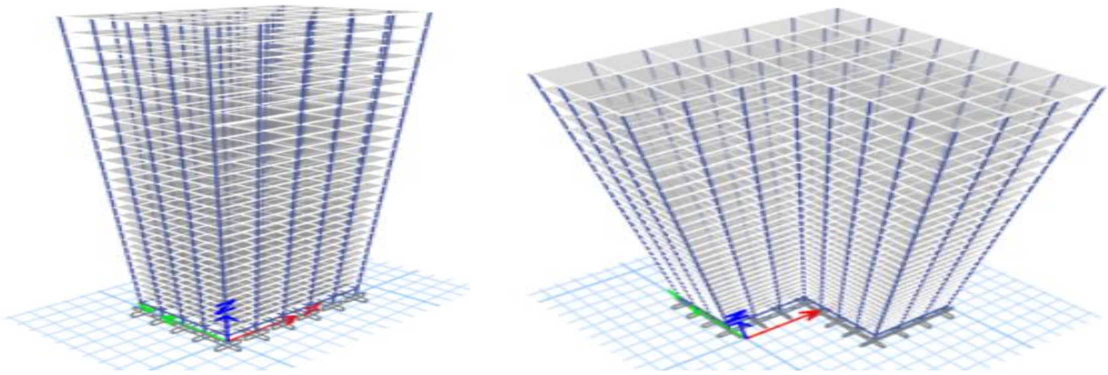
III.Load Combinations

The Structure has been analysed for load combination as per IS 875 part 5 as shown below.

TABLE-3

Sr. No	Load Combination
1	"DL+LL"
2	"1.2(DL+LL+WLX)"
3	"1.2(DL+LL-WLX)"
4	"1.2(DL+LL+WLY)"
5	"1.2(DL+LL-WLY)"
6	"1.5(DL+WLX)"
7	"1.5(DL-WLX)"
8	"1.5(DL+WLY)"
9	"1.5(DL-WLY)"
10	"0.9DL+1.5WLX"
11	"0.9DL-1.5WLX"
12	"0.9DL+1.5WLY"
13	"0.9DL-1.5WLY"
14	"1.2(DL+LL+EQX)"
15	"1.2(DL+LL-EQX)"
16	"1.2(DL+LL+EQY)"
17	"1.2(DL+LL-EQY)"
18	"1.5(DL+EQX)"
19	"1.5(DL-EQX)"
20	"1.5(DL+EQY)"
21	"1.5(DL-EQY)"
22	"0.9DL+1.5EQX"
23	"0.9DL-1.5EQX"
24	"0.9DL+1.5EQY"
25	"0.9DL-1.5EQY"
26	"1.2(DL+LL+SPECX)"
27	"1.2(DL+LL+SPECY)"
28	"1.5(DL+SPECX)"
29	"1.5(DL+SPECY)"
30	"0.9DL+1.5SPECX"
31	"0.9DL+1.5SPECY"
32	"1.5(DL+LL)"
33	"DL+0.5LL"
34	"DL+EQX"
35	"DL-EQX"
36	"DL+EQY"
37	"DL-EQY"
38	"DL+SPECX"
39	"DL-SPECX"
40	"DL+SPECY"
41	"DL-SPECY"
42	"DL+WLX"
43	"DL-WLX"
44	"DL+WLY"
45	"DL-WLY"
46	"DL+0.25LL"

IV.Modelling in Etabs

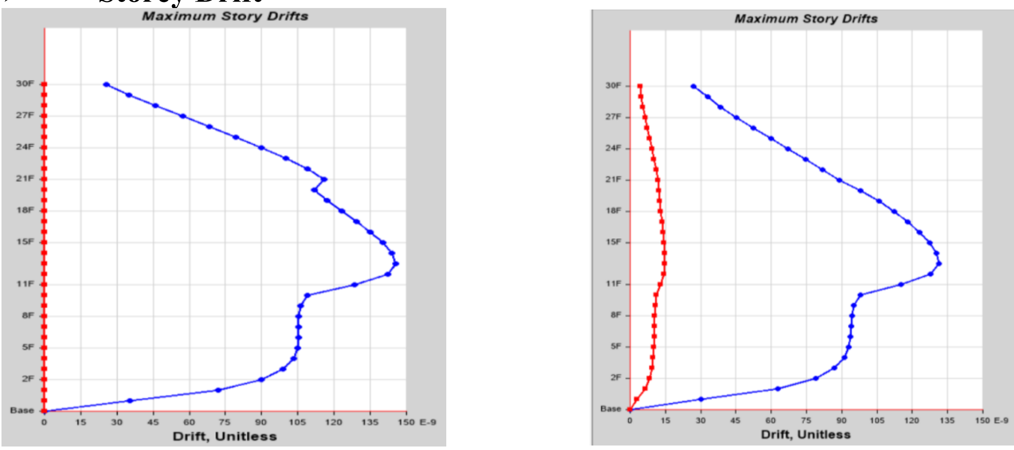


(a) (b)

Fig 2: 3D-View of 30 storey Building (a) Rectangular (b) L-Shape

V.Results

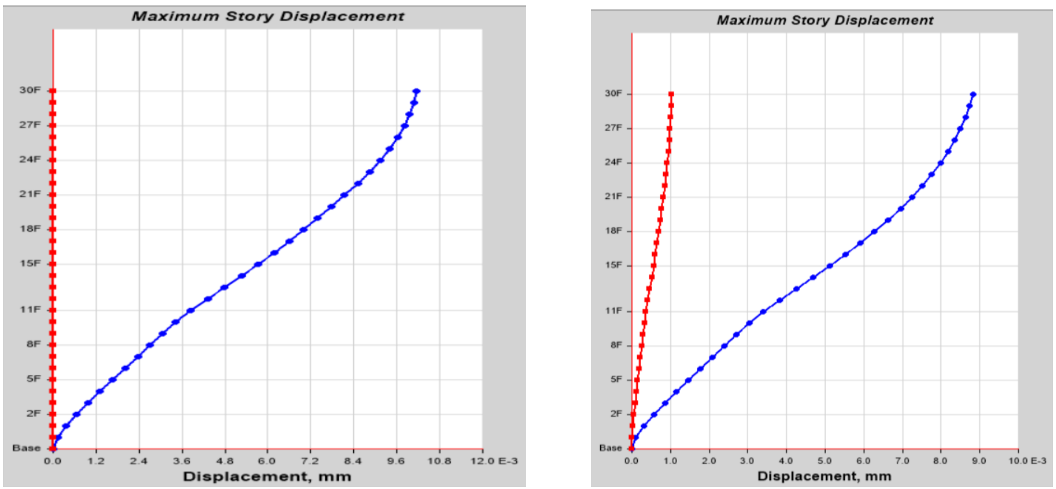
➢ **Storey Drift**



(a) (b)

Fig 3: Storey Drift (a) Rectangular (b) L-Shape

➢ **Max Storey displacement**



(a) (b)

Fig 4: Storey Displacement (a) Rectangular (b) L-Shape

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➢ **Modal Mass participation**

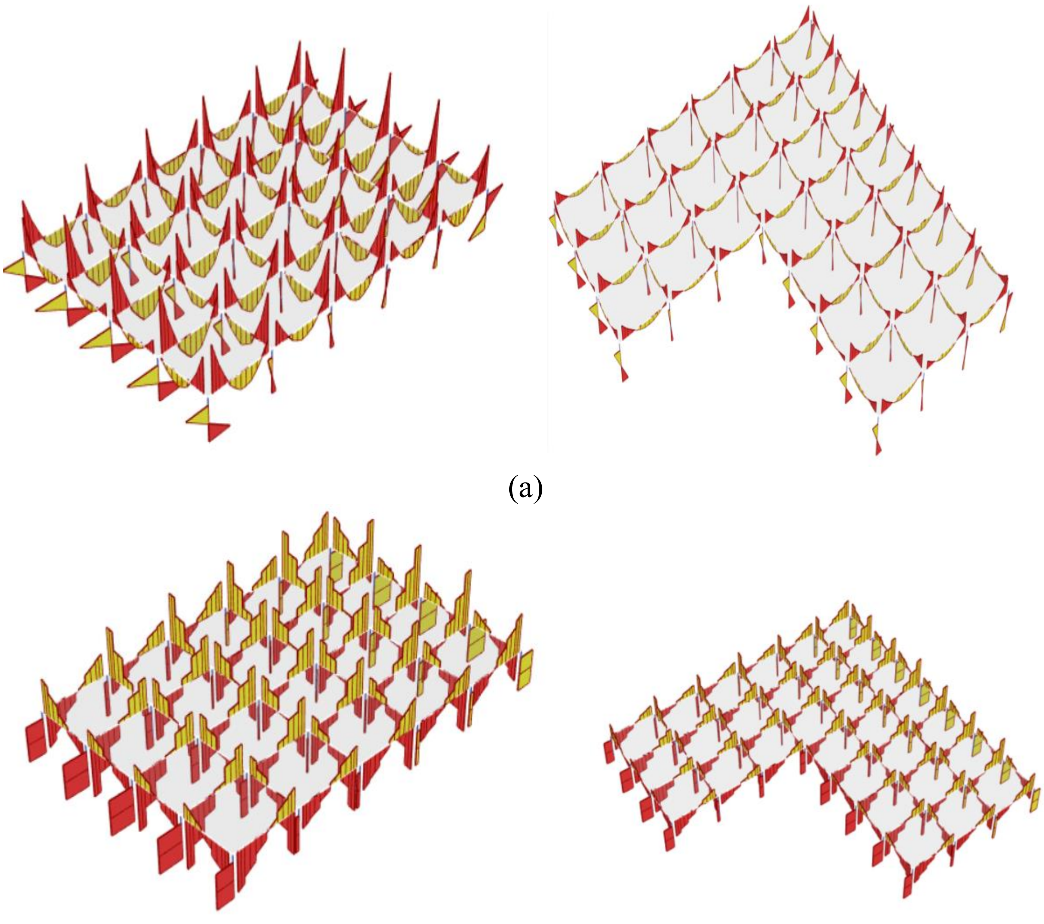
Rectangular Building (TABLE-4)

Mode	Period sec	UX	UY	UZ	RX	RY	RZ
1	4.367	0.7171	0	0	0	0.2881	0
2	4.085	0	0.7042	0	0.3018	0	0
3	3.576	0	0	0	0	0	0.7105

L-Shaped Building (TABLE-5)

Case	Mode	Period sec	UX	UY	UZ	RX	RY	RZ
Modal	1	4.631	0.7252	0.0001	0	2.643E-05	0.2689	0.0059
Modal	2	4.173	0.0016	0.4878	0	0.1896	0.0007	0.2366
Modal	3	3.883	0.0052	0.2397	0	0.0868	0.0019	0.4865

Bending Moment & Shear Force



(a)

(b)

Fig 5: Bending moment & Shear Force at 15th floor (a) Rectangular (b) L-Shape

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➢ Base shear

Rectangular Building (TABLE-6)

Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
EQX	LinStatic			-15353.7353	-8.887E-07	0	0.0001	-1173689	168890.038
EQY	LinStatic			-8.433E-07	-15353.7353	0	1173689.1728	-0.0001	-253335.057
SPECX	LinRespSpec	Max		15353.7266	0.0047	0	0.0126	859673.0407	169815.7715
SPECY	LinRespSpec	Max		0.0047	15353.7286	0	827608.149	0.0166	254444.7621
WLX	LinStatic			-4305.4925	0	0	1.344E-05	-247558.4336	43054.9252
WLY	LinStatic			0	-6725.1082	0	386682.1814	-1.829E-05	-100876.6224

L-shaped Building (TABLE-7)

Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
EQX	LinStatic			-24060.7089	-1.236E-06	0	0.0001	-1861227	176112.1884
EQY	LinStatic			-1.092E-06	-24060.7089	0	1861227.1307	-0.0001	-555344.8572
SPECX	LinRespSpec	Max		24060.7068	890.8509	0	56196.9052	1388142.5944	156760.0252
SPECY	LinRespSpec	Max		895.2002	24060.7161	0	1304439.24	56551.8164	564782.2912
WLX	LinStatic			-8032.7681	0	0	3.313E-05	-461870.3833	20081.9202
WLY	LinStatic			0	-8070.1298	0	464018.6177	-1.195E-05	-145262.3363

➢ Displacement Vs Height of the Building

Storey	Lateral Displacement (mm)	
	Rectangular	L-shape
30F	11.67	14.17
29F	11.67	14.17
28F	11.66	14.17
27F	11.64	14.16
26F	11.59	14.14
25F	11.51	14.10
24F	11.39	14.05
23F	11.23	13.98
22F	11.01	13.89
21F	10.75	13.78
20F	10.42	13.63
19F	10.21	13.36
18F	9.95	13.05
17F	9.66	12.68
16F	9.33	12.27
15F	8.96	11.79

Storey	Lateral Displacement (mm)	
	Rectangular	L-shape
14F	8.55	11.26
13F	8.09	10.67
12F	7.59	10.02
11F	7.05	9.31
10F	6.47	8.54
9F	6.06	8.01
8F	5.61	7.43
7F	5.13	6.80
6F	4.62	6.12
5F	4.07	5.39
4F	3.49	4.62
3F	2.86	3.79
2F	2.20	2.91
1F	1.50	1.98
GF	0.76	1.01
Base	0.00	0.00

➢ Reinforcement

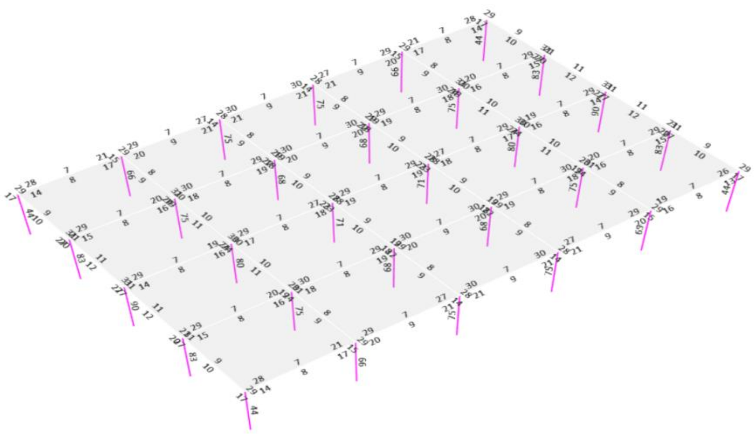

Fig:6
Column and beam reinforcement for rectangular building

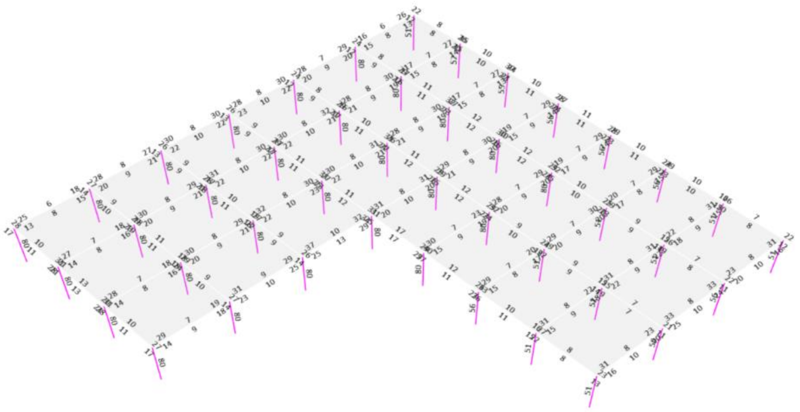

Fig:7
Column and beam reinforcement for L-shaped building

Conclusion

The analysis of multistorey building shows that the lateral displacement is less in rectangular building as compared to L-shaped building and storey drift is more in rectangular building as compared to L-shaped building.

Base shear in earthquake is more in L-shaped building and less in rectangular building, and wind forces are high in case of L-shaped building as compared to rectangular building. Through dynamic analysis, it can be observed that structures with asymmetrical plans experience greater deformation compared to those with symmetrical plans. Reinforcement in Column are also in higher side in L-shaped Buildings. Hence, we should try to for symmetrical plans.

Acknowledgement

This study would not have been possible without the guidance of HOD Siddharth Jain-IIMTU and Prof. Dr. Prashant Kumar, Civil Engineering department.

References

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