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Structural Analysis of High-Rise Building in Different Shape

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ABSTRACT: A high-rise building is a tall building, as opposed to a low-rise building and is defined differently in terms of height depending on the jurisdiction. It is used as a residential, office building, or other functions including hotel, retail, or with multiple purposes combined. The structure of a high-rise building is dominated by lateral forces and these lateral forces are majorly the earthquake loads and the wind loads. Thus, to resist these lateral forces, the stiffness of the building is of prime importance. In this project, we have to do the structural analysis of various multi-storied buildings with different plan configurations like Rectangle and L-shaped configuration. The analysis will be done on models of buildings with different configurations and the models will be prepared using the ETABS software. The existing seismic regulations act as a limiting factor and cannot cover specific behaviour of these buildings. Considering the increasing trend in their construction worldwide, additional investigations are necessary, particularly for structures in seismically active areas. It is necessary to elaborate official codes which will clearly prescribe methods, procedures and criteria for analysis and design of such type of structures. High-rise buildings are exposed to both static and dynamic loads.

KEYWORDS: Lateral force, Earthquake, Stiffness, Seismic regulations, Static and dynamic load.

I. INTRODUCTION

Tall buildings throughout the world are becoming popular day by day. With the advent of modern-day construction technology and computers, the basic aim has been to construct safer buildings keeping in view the overall economics of the project. A high-rise building, apartment tower, office tower, apartment block, or block of flats, is a tall building or structure used as a residential and or office use. Determination of the general shape and all the specific dimensions of a particular structure so that it will perform the function for which it is created and will safely withstand the influences which will act on it throughout its useful life.

But from the structural point of view, it can be defined as a building that its height will be affected by lateral forces resulting from earthquakes and wind forces to extent that such forces will play a major role in the process of design. Based on the distribution of the components of the primary lateral load-resisting system over the building, the structural system of high-rise buildings can be broadly classified as:

- I. Interior Structures: - In interior structural system, the major part of the lateral load-resisting system is located within the interior of the building.
- II. Exterior Structures: - In exterior structural system, the lateral loads resisting system, is located along the building perimeter.

The high-rise structure or building is the necessity of metro cities. The multi-story high rise RC building are more large and less elastic in nature as judge against to compound structures. This study investigates the similarity or comparison between RCC and composite structure under the effect of wind, additional to it compound structure also includes unlike plan configurations. In adding together, the comparative study concludes that the compound structure is bigger elastic in nature and more at risk as compare to RCC structure and the compound option is better than RCC for multi-story structure. Whole study is observed in software analysis. In addition, the comparison of unlike plan configuration shows that the response of parameter such as story displacement, story stiffness, base reaction and time period under effect of wind. The reason of this analysis is to conclude the most efficient shape of construction in horizontal zone.

High-rise buildings remain attractive for constructors throughout the time. Due to their extraordinary presence in the built environment, high-rise buildings have a particular importance and visible feature owing to their height, clearness and domination over other elements of the landscape.

II. METHODOLOGY

Every structure follows a specific way from its planning to design as follows:

- 1) Structural planning of the building.
- 2) Layout plan of building Rectangle and L-shape building.
- 3) Prepare model in ETAB.
- 4) Assign loads to both models.
- 5) Calculation of assign loads.
- 6) Analysis of the building Rectangle and L-shape building.
- 7) Prepare Drawing and detailing of the structural elements.
- 8) Preparation of result tables and graphs for rectangle and L-shape building.
- 9) Compare rectangle and L-shape building.
- 10) It is the responsibility of the structural engineer to construct the building structurally good, considering all the loads acting on the building. There are so many methods of conducting this design we use E-tab software.

III. OBJECTIVES

1. To examine a G+20-storey residential building for distinctive loads combinations using ETABS software.
2. Study of displacement, drift, overturning, shear forces, Reactions and bending Moments.
3. Compare the analysis different shape of model with software calculations
4. To analyze the building using IS code 1893 (part 1): 2002 for seismic analysis.
5. To develop, design and analysis model of the High-rise structure in ETABS.
6. To verify deflection obtained by ETABS with IS code Limit.
7. Modelling of G+20-storey building and application of different loads on ETABS, load calculations due to different loading combinations, analysis and design of structure on ETABS.

IV. SEISMIC DESIGN FORCE

The seismic base shear is the total design lateral force at the base of a building. The base shear is calculated using the design ground motion described in the previous section and modified to account for the structural characteristics and importance placed on a building. Earthquake shaking is random and time variant. But most design codes represent the earthquake-induced inertia forces as the net effect of such random shaking in the form of design equivalent static lateral force. This force is called as the seismic design base shear V_b and remains the primary quantity involved in force-based earthquake-resistant design of buildings. This force depends on the seismic hazard at the site of the building represented by the seismic zone factor Z . Also, in keeping with the philosophy of increasing design forces to increase the elastic range of the building and thereby reduce the damage in it, codes tend to adopt the importance factor i for effecting such decisions. Further, the net shaking of a building is a combined effect of the energy carried by the earthquake at different frequencies and the natural periods of the building. Codes reflect this by the introduction of a structural flexibility factor s_a/g . To make normal buildings economical, design codes allow some damage for reducing cost of construction.

V. ZONE FACTOR

Zone II:

Low intensity zone-It covers about 40.93% area of the country. It consists of major parts of peninsular region and Karnataka Plateau.

Zone III:

Moderate intensity zone-It covers about 30.79% area of the country.

It consists of Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, Parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Odisha, Andhra Pradesh, Tamil Nadu and Karnataka.

Zone IV: Severe intensity zone-It covers about 17.49% area of the country. It consists of parts of Jammu and Kashmir, Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, Northern Parts of Uttar Pradesh, Bihar, West Bengal, parts of Gujarat, small portions of Maharashtra near the coast and Rajasthan.

Zone V:



Very severe intensity zone-It covers 10.79% area of the country.

It consists of the entire north-eastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Rann of Kutch in Gujarat, part of North Bihar and Andaman & Nicobar Islands

Where Z= Zone factor = 0.16 for Zone III, IS: 1893 (Part 1):2002

Table 1. Zone Factor For Various Zones

Seismic Zone Factor (1)	II (2)	III (3)	IV (4)	V (5)
Z	0.10	0.16	0.24	0.36

VI. PROBLEM STATEMENT

A building having plan dimension 36 X 28m, Floor to floor height is 3m, having 35 storied building. Column spaced at 4m centre to centre. For this study different size of column use at different stories of building such as 1 to 10 stories column size 600x600mm, 11 to 15 stories columns size 500x500mm and 16 to 20 stories column size is 400x400mm. For this analysis various loads are considered such as dead load, live load and wind load respectively. The combination of loads consider according to IS 875(Part 5)-1987. Shape of building is 1. Rectangular Plan, 2. L-shape Plan.

Table 2. General Data for Design

BUILDING DESCRIPTION	
Plan Dimension	Length=36, Width=28
Total Height of Building	57.9
Height of each storey	3m
Periphery Beam Dimension	450x650
Main Beam Dimension	400x400
Column Dimension for 1to 15 Storey	600x600
Column Dimension for 16 to 30 Storey	500x500mm
Column Dimension for 31 to 35 Storey	400x400mm
Support conditions	Fixed
Type of structure	2
Seismic zone	V
Slab thickness	225mm
Thickness of main wall	230mm
Height of parapet wall	0.90m

Table 3. General Data For Material Specification

MATERIAL SPECIFICATIONS	
Grade of Concrete, M40	fck= 40N/mm ²
Grade of Steel	fy= 415N/mm ²
Density of Concrete	γ _c = 25kN/m ³
Density of Brick walls considered	γ _{brick} = 20kN/m ³

VII. LOAD COMBINATION

Load combination between dead load, live load, wind load and seismic load as per 875(Part 5),1987

1. 1.5(DL+LL)
2. 1.2(DL+LL+WX)
3. 1.2(DL+LL+WY)
4. 1.2(DL+LL+EQX)
5. 1.2(DL+LL+EQY)
6. 0.9(DL+LL+WX)
7. 0.9(DL+LL+WY)

- 8. 0.9(DL+LL+EQX)
- 9. 0.9(DL+LL+EQY)

VIII. TYPICAL LAYOUT OF PROBLEM STATEMENT

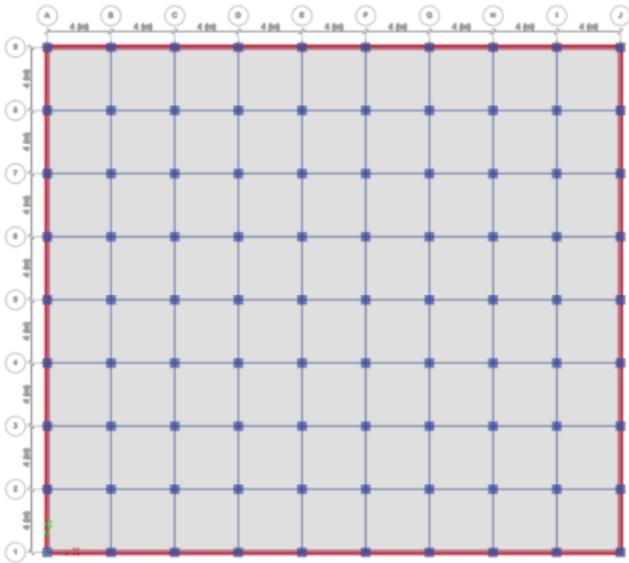


Fig. 1 Rectangle Shape Plan View

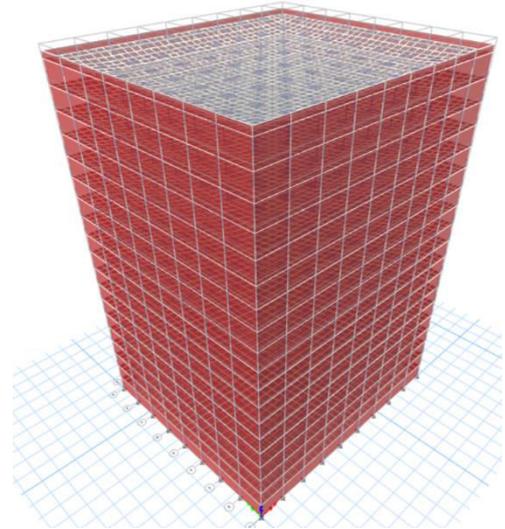


Fig2. Rectangle Shape 3D View

IX. RESULT

1. MAXIMUM STORY DRIFT

Table.4 Maximum Story Drift

BUILDING SHAPE	STORY	STORY DRIFT
Rectangle	Story 8	2.033
L- Shape	Story 12 to story 14	4.306

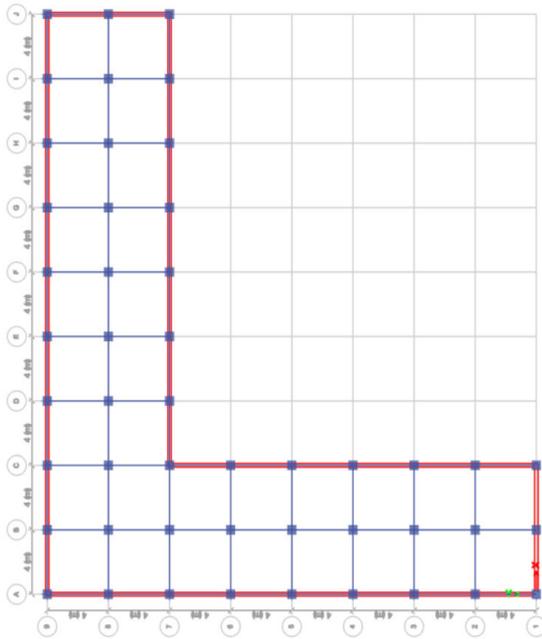


Fig 3. L-Shape Plan View

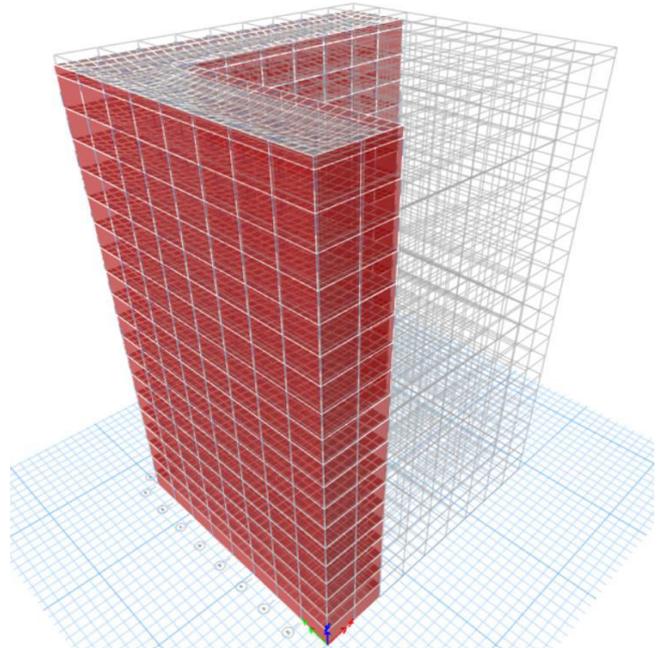


Fig 4. L-Shape 3D View

2. MAXIMUM STORY DISPLACEMENT

Table 5. Maximum Story Displacement

BUILDING SHAPE	STORY	STORY DISPLACEMENT (MM)
RECTANGLE	STORY 20	0.09915
L- SHAPE	STORY 20	4.154

3. STORY OVERTURNING MOMENT

Table 6. Story Overturning Moment

BUILDING SHAPE	STORY	MAX. OVERTURNING (KN/M)	MIN. OVERTURNING (KN/M)
RECTANGLE	STORY 8 TO STORY 10	0.236419	-789.2369
L- SHAPE	STORY 20	488.311	0



4. RECTANGLE SHAPE MAXIMUM SHEAR BASE

Table 7. Rectangle-Shape Maximum Shear Base

Output Case	FX (KN)	FY (KN)	FZ (KN)	MX (KN)	MY (KN)	MZ (KN)
Dead	-5468	-5468	796422.1698	12885982	-14480621	-16404
Live	0	0	87552	1400832	-1575936	0
EQ_X	- 142240.4468	0	87552	1400832	-6128660	2275657
EQ_Y	0	- 142240.4468	0	4552724.113	0.000001024	-2559948
WIND LOAD_X1	-2941.0971	0	0	0	-94106.0212	47057.5533
WIND LOAD_Y1	0	-5169.8972	0	165420.7404	0	- 93058.1499

5. L-SHAPE MAXIMUM SHEAR BASE

Table 8.L-Shape Maximum Shear Base

Output Case	FX (KN)	FY (KN)	FZ (KN)	MX (KN/m)	MY (KN/m)	MZ (KN/m)
Dead	-2016	-2016	347175.3701	7547904.229	-4476780	15120
Live	0	0	102000	2203200	-1264800	0.000005922
EQ_X	-48291.9127	-9.484E-07	0	0.00004059	-1656853	1030888.649
EQ_Y	- 0.000001162	-48017.6674	0	1644559.074	-0.0000474	- 610385.0568



WIND LOAD_X1	- 136183.3971	- 0.000002033	0	0.0001	-4130445	2885533.953
WIND LOAD_Y1	-6.922	-40118.6972	0	1224132.5	- 0.00002921	- 536798.9497

X. CONCLUSIONS

- The G+20 residential building of Rectangle shape and L-shape has been analysed and deigned using ETABS. Seismic forces have been considered and the structure is designed as an earthquake resistant structure.
- In building L-shape storey 12 to 14, storey drift high as compared to Rectangle shape of building.
- In building L-shape storey 20, storey displacement is high as compared to rectangle shape of building.
- In building L-shape storey 20, storey over turning moment is 0 and rectangle shape of building. Story overturning moment on storey 10 is in minus.
- for rectangle shape of building maximum shear base and for L-shape of building maximum shear base is shown in table Rectangle-Shape Maximum Shear Base and L-Shape Maximum Shear Base for different load cases

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