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COMPARATIVE ANALYTICAL STUDY OF HIGH RISE BUILDINGS WITH SHEAR WALLS SUBJECTED TO SEISMIC LOADS AND WIND LOADS

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ABSTRACT

In order to design a structure to resist seismic and wind loads, the forces on the structure must be specified. It is very essential to consider the effects of lateral loads induced from wind and earthquakes in the design of reinforced concrete structures, especially for high-rise buildings. In this research both the lateral effects according to Indian Code of practice are studied separately on same buildings and the results are compared. The lateral effects are studied on various buildings such as G+10, G+15, G+20, G+25 and G+30 separately and the comparisons are made. In this paper a computer program ETABS has been used to analyze the reinforced concrete tall buildings with shear walls at four corners subjected to seismic and wind loads. Response spectrum analysis has been used for the analysis of seismic loading. The buildings for seismic evaluation are considered to be in highest seismic zone of India and the buildings for wind forces are considered to be subjected to highest basic wind speed of India. This paper also explains how the effect of individual lateral loads varies on different heights of building.

Keywords- *Lateral loads, High-rise buildings, Indian code, ETABS, Shear wall, Response spectrum analysis.*

I. INTRODUCTION

Due to the rapid growth of the world's population and decrease of land to accommodate new trend of construction has been developed. In this trend or strategy the buildings which are constructed are not expanding on the ground but they are expanding towards sky or increasing in height. As the time is passing the architects are designing the structures or buildings which wants to talk to the sky. Thus this buildings needs to be designed with most priority so that it can withstand the major natural hazard since this buildings gives shelter to many and are used for various purposes. As the height of the structure increases it becomes more intense to lateral loads. Thus buildings are designed to resist the lateral load such as earthquake forces, wind forces etc. To resist this lateral force the functional planning of a building affects the way in which it can accommodate its structural skeleton. The lateral load is resisted by using bearing wall or shear wall, moment resisting frames, dual system, tube system. Two main types of structural systems, which are concrete frame systems and concrete frame-wall systems, are used by civil engineers to resist external vertical and horizontal loads for concrete structures. Experimental and analytical research demonstrated that the concrete frame wall buildings have display better seismic performance and resistance compared to concrete frame system. In order to design a structure to resist wind and earthquake loads, the forces on the structure must be specified. The exact forces that will occur during the life of the structure cannot be anticipated. Most National Building Codes identify some factors according to the boundary conditions of each building considered in the analysis to provide for life safety. A realistic estimate for these factors is important. However the cost of construction and therefore the economic viability of the project is essential.

II. OBJECTIVE

The aim and objective of this study comprises of the following

- To know the effect of lateral load on high rise buildings.
- To know which lateral force i.e loads generated due to earthquake or lateral loads generated due to wind pressure are dominating on structure.
- To compare the parameters such as base shear, storey displacements, over-turning moments etc. of different heights of buildings located in highest seismic zone i.e zone-V of India and with the buildings subjected to highest wind speed in India.

III. SHEAR-WALLS

The walls in building which resist lateral loads originating from winds or earthquakes are known as shear walls. Reinforced concrete (RC) buildings often have vertical plate-like RC walls called shear walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake and wind loads downwards to the foundation. Well designed shear walls not only provide adequate safety but also give a great measure of protection against costly non-structural damage during seismic and wind actions. In multi-story structures, shear walls are critical, because in addition to preventing the failure of exterior walls, they also

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support the multiple floors of the building ensuring that they do not collapse as a result of lateral movement. Finally, the L-shaped shear walls exhibit a more improved seismic performance than that of rectangular shear walls and are usually used at the corners of the buildings.

IV. RESPONSE SPECTRUM ANALYSIS

This method is also known as Modal Method or Mode Superposition Method. The method is applicable to those structures where modes other than the fundamental one significantly affect the response of the structure. This method is based on the fact that, for certain forms of damping which are reasonable models for many buildings the response in each natural mode of vibration can be computed independently of the others, and the modal responses can be combined to determine the total response. In this method the response of Multi-Degree of Freedom (MDOF) is expressed as the superposition of each Single-Degree of Freedom (SDOF) system, which is then combined to compute the total response. This is required in many building codes for all except for very simple or very complex structures. Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure.

Design Lateral Force At Each Floor In EachMode

The peak lateral force (Q_{ik}) at floor *i* , in mode "k" is given by

$$Q_{ik} = A_k Ø_{ik} P_k W_i$$

Where,

A_k = Design horizontal spectrum value using natural period of vibration (T_k) of mode k.

= $(Z \, I \, S_a) / (2 \, R \, g)$

V. WIND ANALYSIS

Buildings shall also be design with due attention to the effects of wind on the comfort of people inside and outside the building. In general wind speed in the atmospheric boundary layer increases with height from zero at ground level to a maximum height called the gradient height. The variation with height depends primarily on the terrain conditions. However, the wind speed at any height never remains constant and it has been found convenient to resolve its instantaneous magnitude into an average or mean value and a fluctuating component around average value. The average value depends on the averaging time employed in analyzing the meteorological data and this averaging time varies from few seconds to several minutes. The magnitude of fluctuating component of the wind speed which is called gust , depends on the averaging interval, greater is the magnitude of the gust speed. The estimation of wind on tall building is carried out by analytical method given in the code [IS: 875 (Part 3)-1987]. The basic wind speed and all the relevant co-efficient are taken from the code mentioned. The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity as follows :-

$$p_z = 0.6 \, V_z^2$$

Where,

p_z = Design Wind Presure In N/mm^2 at any Height

V_z = Design Wind Velocity In m/s at any Height

VI. METHODOLOGY

In order to carry out the comparative analysis work the various high rise buildings with shear walls subjected to lateral loads are considered. The considered buildings are G+10, G+15, G+20, G+25 and G+30. The first storey is considered to be as stilt floor

Modeling Discription

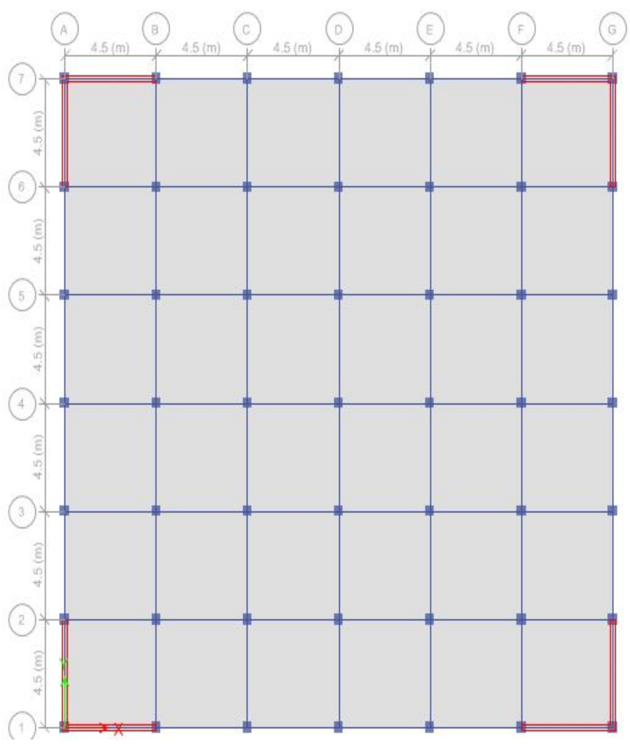
The building taken for evaluation is of 27m X 27m = 729 sq.m with different heights, by keeping the plan same for all buildings. The height of buildings are as indicated.

G+10 = 38.5 m G+15 = 56.0 m
G+20 = 73.5 m G+25 = 91.0 m

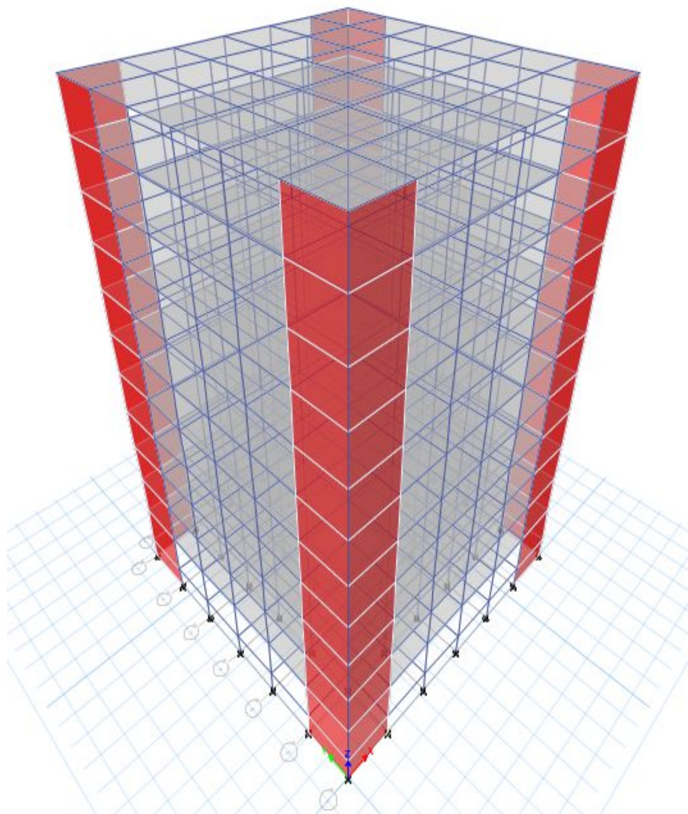
G+30 = 108.5 m

S.No	DISCRIPTION	INFORMATION
1	Symmetrical Plan Typical Storey Height Type of structure	X and Y - Direction 3.5 m RCC frame structure
2	Cross-section Details • Column • Beam • Slab [thickness] • Shear wall [thickness]	450 mm X 450 mm 230 mm X 300 mm 125 mm 230 mm
3	Modelling Assumptions • Diaphragm • Joints • Footings	Rigid Rigid Fixed
4	Dead Load IS: 875- Part (I) • Brick Masonary • Floor Finish	12 kN / m , 3 kN / m 1.0 kN / m^2
5	Live Load IS: 875- Part (II)	3.0 kN / m^2
6	Wind Load IS: 875- Part (III) • Basic Wind Speed • Risk Co-efficient (k_1) • Terrain Category • Class of Building • Topography Factor (k_3) • Windward Co-efficient • Leeward Co-efficient	55 m / sec 1.08 Category - 2 Class - B 1.0 0.8 0.5
7	Seismic Load • Seismic Zone - V • Importance Factors • Type Of Soil • Response Reduction Factor	Z = 0.36 I = 1.5 Medium Hard R = 5
8	Grade of Concrete and Steel	M 25 , Fe 500

PLAN OF THE BUILDING



3-D MODEL OF THE BUILDING



NOTE:-

All the models are same except number of stories. Here 3-D model of G+10 building is shown.

VII. COMPARITIVE RESULTS

Base Shear

The base shear is obtain for design load combinations from Indian code for seismic and wind effect and the values are plotted in Fig-1. The buildings are subjected to highest seismic zone of India and also they are subjected to highest basic wind speed of India. It is observed that the base shear due to seismic effect is less than base shear due to the effect of wind as the number of storeys increases.

For G+10 building due to wind, percentage increase in base shear is 17.00% of seismic effect
For G+15 building due to wind, percentage increase in base shear is 17.20% of seismic effect
For G+20 building due to wind, percentage increase in base shear is 18.66% of seismic effect
For G+25 building due to wind, percentage increase in base shear is 23.12% of seismic effect
For G+30 building due to wind, percentage increase in base shear is 26.20% of seismic effect

Maximum Storey Displacement

The maximum storey displacement [MSD] is obtain for lateral loads i.e for seismic and wind effect and the values are plotted in Fig-2. It is observed that the maximum storey displacement due to seismic effect is less than maximum storey displacement due to the effect of wind as the number of storeys increases. In the initial stage stages when the height of the structure is less it is observed that maximum storey displacement is higher for seismic effects and lower for wind effect.

For G+15 building due to wind, percentage increase in MSD is 19.0% of seismic effect
For G+20 building due to wind, percentage increase in MSD is 19.0% of seismic effect
For G+25 building due to wind, percentage increase in MSD is 18.4% of seismic effect
For G+30 building due to wind, percentage increase in MSD is 12.1% of seismic effect

Overturning Moment

The overturning moment [OTM] is obtain for lateral loads i.e for seismic and wind effect and the values are plotted in Fig-3. It is observed that the overturning moment due to seismic effect is more than the overturning moment due to the effect of wind as the number of storeys increases.
For G+10 building due to seismic, OTM is 2.61 times OTM of wind effect
For G+15 building due to seismic, OTM is 1.43 times OTM of wind effect
For G+20 building due to seismic, OTM is 1.15 times OTM of wind effect
For G+25 building due to seismic, OTM is 1.12 times OTM of wind effect
For G+30 building due to seismic, OTM is 1.09 times OTM of wind effect

Base Shear Due To Seismic Effect
In zone-V of India the increase of base shear for the increase in number of storeys by keeping the G+10 building as constant. For G+15, G+20, G+25, G+30 buildings ; the variation of base shear is 1.51, 2.02, 2.48, 2.96 times base shear of G+10 building.

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Base Shear Due To Wind Effect
The base shear when buildings are subjected to highest basic wind speed of India by keeping G+10 building as constant. For G+15, G+20, G+25, G+30 buildings ; the variation of base shear is 1.51, 2.05, 2.61, 3.19 times base shear of G+10 building.

Maximum Storey Displacement Due To Seismic Effect
In zone-V of India the increase of maximum storey displacement for the increase in number of storeys by keeping the G+10 building as constant. For G+15, G+20, G+25, G+30 buildings ; the variation of maximum storey displacement is 1.46, 2.95, 6.06, 10.48 times maximum storey displacement of G+10 building.

Maximum Storey Displacement Due To Wind Effect
The maximum storey displacement when buildings are subjected to highest basic wind speed of India by keeping G+10 building as constant. For G+15, G+20, G+25, G+30 buildings ; the variation of maximum storey displacement is 3.22, 7.21, 13.27, 21.70 times maximum storey displacement of G+10 building.

Overturning Moment Due To Seismic Effect
In zone-V of India the increase of overturning moment for the increase in number of storeys by keeping the G+10 building as constant. For G+15, G+20, G+25, G+30 buildings ; the variation of overturning moment is 1.17, 1.67, 2.53, 3.50 times overturning moment of G+10 building.

Overturning Moment Due To Wind Effect
The overturning moment when buildings are subjected to highest basic wind speed of India by keeping G+10 building as constant. For G+15, G+20, G+25, G+30 buildings ; the variation of overturning moment is 2.15, 3.78, 5.92, 8.58 times overturning moment of G+10 building.

VIII. CONCLUSIONS

- In the initial stage stages when the number of storeys of the structure are less it is observed that base shear is higher for seismic effects and lower for wind effect. As the storeys increases base shear is higher for wind effect and lesser for seismic effect.
- In the initial stage stages when the number of storeys of the structure are less it is observed that maximum storey displacement is higher for seismic effects and lower for wind effect. As the storeys increases maximum storey displacement is higher for wind effect and lesser for seismic effect.
- It is observed that the overturning moment due to seismic effect is more than overturning moment due to the effect of wind as the number of storeys increases.

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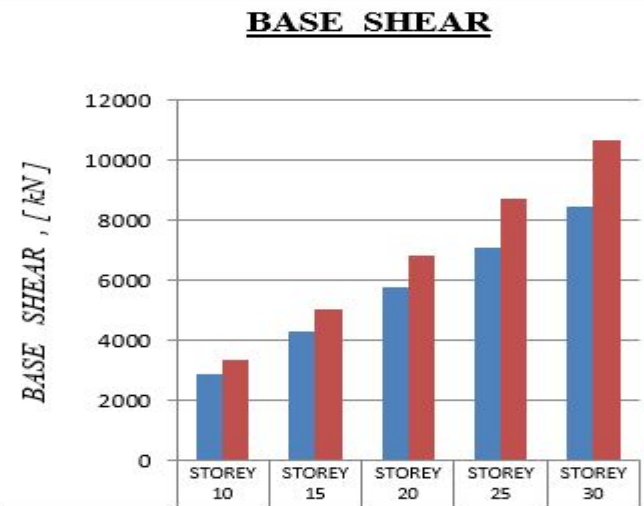
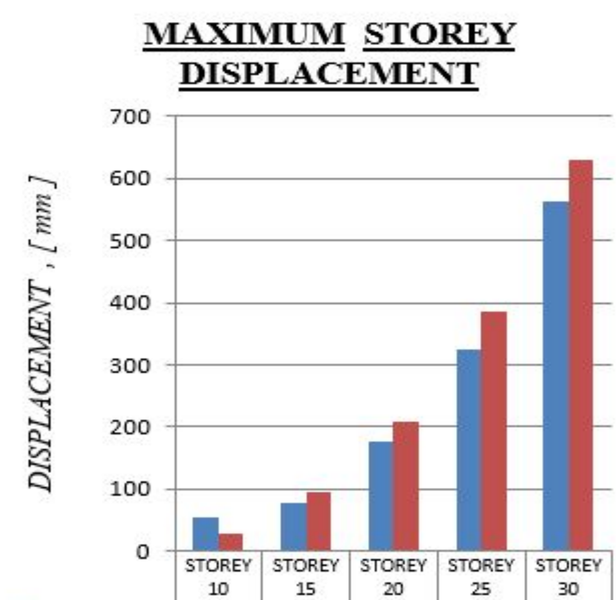


	STOREY 10	STOREY 15	STOREY 20	STOREY 25	STOREY 30
SEISMIC ACTION	2848	4306	5765	7075	8439
WIND ACTION	3332	5046	6841	8711	10650

Fig-1 Base Shear Vs Storeys



	STOREY 10	STOREY 15	STOREY 20	STOREY 25	STOREY 30
SEISMIC ACTION	53.6	78.7	175.6	325.2	561.8
WIND ACTION	29	93.5	209	384.9	629.3

Fig-2 Maximum Storey Displacement Vs Storeys

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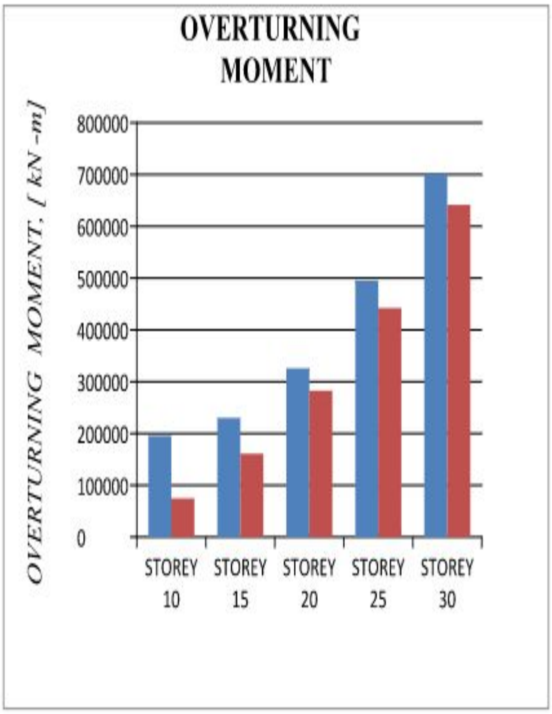

Fig-3 Overturning Moment Vs Storeys