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Comparison of Influence of Wind and Earthquake Forces on Low-Rise and High-Rise Multi Story Structures

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ABSTRACT

This paper presents a comparative study of the severity effect of earthquake and wind forces on a multistory building. It is very essential to consider the effects of lateral loads in the design of reinforced concrete structures. It determines the critical design loading for a multistory buildings subjected to different basic wind speeds (39, 44, 47, 50, 55 m/s) and earthquake zones(II,III,IV,V). In the present study the response of low-rise and high-rise multistory buildings are analyzed with earthquake loads based on IS 1893:2002 and for wind loads IS 875:1987 code. When a building is situated in a particular wind and earthquake zone, the major designing loads for the particular building can be decided using these results. After a detailed study the low-rise buildings are more affected when subjected to earthquake forces and high-rise structures are equally effected by wind forces when compared to earthquake forces.

INTRODUCTION

Due to the scarcity of land there has been increased demand for land. So there has been a considerable increase in the number of tall buildings, both residential and commercial and the modern trend is towards the taller structures.

Considering the increasing population as well as lack of horizontal expansion is not a reasonable solution. Then the only solution for the growing demand is the construction of the multi-story structures in the available land. The development of high strength concrete, higher grade steel ,new construction techniques and advanced computational technique has resulted in the emergence of a new generation of tall structures that are flexible, low in damping, slender and light in weight.

In high risk seismic zone the seismic performance of structures are considered as the primary importance on the other hand which influence seismic performance , may be the effect of impact forces resulting from earth movement greater than the forces caused by wind loads and consequently, Seismic loading determines form and final design of the structure.

The aim of the project is to study the comparisons of the effects of the influence of the wind and seismic forces on the low rise and high rise buildings.

According to IS 456: 2000 , specifies either the use of wind or earthquake load. With this assumption in respect to the all international codes and standards, wind and earthquake loads never simultaneously apply on the structure.

The wind and earthquake forces are never applied on a building at a single time. As an extension to that the analysis is carried out in two different phases.

Phase 1: Comparison of wind forces on both low rise and high rise buildings.

Phase 2: Comparison of seismic forces on both low rise and high rise buildings.

This thesis deals with comparative study of wind behavior of high rise structures building frames under the wind effect as per 875(Part-III):1987 static analysis and earthquake forces on low and high rise structures under the earthquake loading as per IS 1893:2002. A comparison of analysis results in terms of Maximum displacements, wind forces, story drift and base reaction has been carried out.

Objectives of the Present Study:
The main objectives of the present study are as discussed below.

1. Comparison of severity of forces acting on the structure.
2. To obtain the maximum design driving force for a low rise story as well as the high rise multistory structure.
3. To study the structural response of forces acting on the structure asthe height of the building increases.
4. To study the variation of response of the forces between low rise andhigh rise multistory structures.

LITERATURE REVIEW

There are few journals presented by scholars, in which they performed the detail study on Wind and Earthquake forces acting on the structures and explained various types of methods and used different software's for the analysis of such building. In this chapter, the detail description of such studies are presented in the reference form.

K. R. C. Reddy, (et.al.,) [1] The purpose of this research is to present a comparative study of wind and earthquake loads to decide the design loads of a multistoried building. The significance of research is to estimate the design loads of a structure when subjected to wind and earthquake loads in every earthquake zone. The research design made use of equivalent lateral load method for the calculation of the forces on the structures. Research considered the wind load as stochastic and time dependent.

Suchita Hirde (et.al.,) [2] The paper presented a study on the severity of earthquake forces against wind forces for multistory RCC building. Themain aim is to analyze the multistory structure situated in wind zone VIand compare its performance to the buildings situated in zone V.

Hemil M .Chauhan (et.al.,) [3] The paper presented a study on thecomparative study of wind forces on high rise buildings. For analysis he used ETABS software with four terrain categories and six different wind speeds.

He performed the analysis on 60m and 120m building. In static analysis, both buildings give almost same values of shear forces & bending moments. IS present code gives increased values of base shear compared to IS Draft code.

John D.Holmes (et.al) [4] The paper describes a comparison of wind load calculations on three buildings with different wind loading codes and standards from the Asia-Pacific Region. He performed an analysis on the low, medium, and high rise structures.

Tarek A.Awida (et.al.,) [5] The paper presented a study on the extensive study for the structural behavior of low / medium / high rise office buildings. Three dimensional finite element techniques through ETABS software are used in conducting analysis for structures considering the plan building with different heights ranging from five to fifty typical office stories are investigated in this study.

Umakant Arya(et.al) [6] The paper studied the structural response of building frame on sloping frame due to the effect of change in wind velocity on the building. He considered three different heights of building.He used a software program known as STAAD - PROv8i.

M.D. Kevadkar (et.al.,) [7] The paper studies the susceptibility of the lateral load forces on the structure. For this analysis an R.C.C structure is modeled using the computer aided program E-TABS to find out the effective lateral load system during earthquake. He modeled a 13 storied building for carrying out the analysis used pushover analysis. He concluded that steel bracings reduce flexure and shear demands on beams and columns andtransfer the lateral load through axial load mechanism.

MODELLING, METHODOLOGY AND ANALYSIS

The E-TABS software is used to develop 3D model and to carry out the lateral load analysis. The lateral loads as wind and earthquake loads to be applied on the buildings are based on the Indian standards. The study is performed for every seismic zone as per IS 456:2000 (Dead load, Live Load)& IS 1893:2002 (Earthquake load), IS875: 1987 (Wind Load). The buildingconsists of reinforced concrete and brick masonry elements.

This study is attempted in following steps:

1. Selection of building plan dimensions. (12m *12m).
2. Selection of the low – rise story building height as 15m (G+4) and highrise story building height as 36m (G+11).
3. Selection of 5 wind zones (39, 44, 47,50 and 55 m/s) as per IS - 875 (part-III):1987.
4. Selection of different earthquake zones by taking different zone factors.
5. Modeling of building frames using ETABS software.
6. Analysing different building frames with different heights (15m, 36m) in different earthquake zones (zone2,3,4,5) and applying different wind speeds (39, 44, 47, 50, 55 m/s).
7. Comparative study of results as Max displacements, story wise displacement, Maximum story shear .

Design Example:
A symmetric building plan is considered for the study. For a low - rise building G+4 is considered and for high – rise multistory structure G+11 is considered. Response spectrum analysis is carried out for earthquake analysis using the software Etabs. Wind response for a building is considered based on the wind forces generating from different wind speeds. The applied roof load should be 50 % of live load.

Phase 1: Earthquake Analysis
Response spectrum analysis is carried out to determine the maximum response of a structure in case of displacements, story shears and storydrifts.

Seismic motion consists of horizontal and vertical ground motions, with the vertical motion usually having provided against gravity loads.

However, in practice all buildings are flexible to some degree. For a structure that deforms slightly, there by absorbing some energy, the force will be

The design lateral force or design seismic base shear (V_B) along the principal direction. $V_B = A_h W$

A_h = Design horizontal seismic coefficient,W = Seismic weight of the building.

The design horizontal seismic coefficient (A_h) is given by

Where Z = zone factor, Z=0.10 for zone II, Z = 0.16 for zone III , Z =0.24 for zone IV , Z = 0.36 for zone V, I = importance factor , R =response reduction factor, R = 5 and S_a/g = spectral acceleration.

The fundamental natural period (T_a) is taken for moment resisting framebuilding without brick infill panels as

$T_a = 0.075h^{0.75}$, Where , h = Height of the building in m.Distribution of design force (Q_i) is given by
$Q_i = V_B W_i h_i^2 / \Sigma W_j h_j^2$

Where Q_i = Design lateral force at floor i , W_i = Seismic weight of floor i ,h_i = height of floor i .

Phase 2: Wind Analysis
Wind loading on a tall building not only acts over a larger surface area butalso with greater intensity at greater height and with a large moment arm about the base than on a low rise building.

Wind loading on a low-rise building has an insignificant influence on the design of the structure, wind on a high rise building can have a dominant influence on its structural arrangement and design.

The calculation of the wind pressure force on the building is applied according to IS 875.3:1987.

The basic wind speed is applicable at 10 m height above mean groundlevel for different zones of the country. The Design wind pressure (P_Z) in N/mm^2 at height Z can be determined by $P_Z = 0.6 V_Z^2$

Design wind speed (V_Z) in m/s at height Z. $V_Z = V_b k_1 k_2 k_3$

RESULTS AND DISCUSSIONS

The lateral forces acting on the structure such as wind and earthquake forcesproduce a sway movement of the building as a result the structure produces lateral displacement of the building. The maximum forces that could act on the building when subjected to the lateral forces are the storey shears. The effect of the lateral forces on the building are compared according to the storey displacements and storey shears. The effect is studied based on the comparsion of lateral displacements and storey shears in terms of the forces and a graphical representation is made to explain the impact of these forces.

CONCLUSIONS

In this study, the multistoried building excited to earthquake forces and windforces for different seismic zones and wind forces are studied. From the modeling and analysis of these building, the following conclusions are drawn out.

- The wind forces are found to be equally dominating for the high rise story. Low rise multistory structures are three times more affected due to earthquake than wind forces. The low rise stories are unaffected by wind forces.
- The displacements, story shears increase as the earthquake zone increases. The high rise stories are equally influenced by the wind and earthquake forces and the wind influence increases if the height increases further.
- The base shear earthquake forces are approximately equal for both low rise and high rise building. The low rise structures are equally vulnerable as much as high rise structures from earthquake forces.
- It is observed that, the lateral forces excited on the structure have shownincreasing severity with increase in the wind speed and earthquake zone factor.
- When earthquake force effects observed on the buildings, the low rise buildings shows higher influence to earthquake forces when compared to high rise building.
- When the lateral forces exerted on high rise buildings, the observed order of the effects are wind speed 55, zone5, wind speed 50, wind speed 47, wind speed 44, zone4, wind speed 39, zone3, and zone2.
- From this, it can also be concluded that, the earthquake forces have shown more severity comparatively with wind forces on a low rise , when the effects
- observed , are in the order as zone5, zone4, zone3,wind speed 55, ,wind speed50, zone2,wind speed 47,wind speed 44, ,wind speed 39..

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