International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

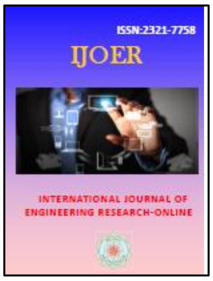
Vol.5., Issue.2, 2017
March-April

RESEARCH ARTICLE

ISSN: 2321-7758

SEISMIC ANALYSIS OF TALL BUILDING FOR DIFFERENT EARTHQUAKE ZONES

E.RAVIKUMAR[1], P .RAGHAVA[2], Dr.T.SURESH BABU[3]
[1]M.Tech student, IV semester, Visvodaya engineering College,Kavali, India.
eluguravivec@gmail.com
[2]Assistant Professor, Department of Civil Engineering Visvodaya engineering College, Kavali, India.
[3]Professor & Head, Department of Civil Engineering Visvodaya engineering College, Kavali, India.



ABSTRACT

The ground shaking induces vibrations in the structure and the resulting deformations can cause significant damage and possibly collapse of the structure. Dynamic analysis can be used to determine from the acceleration records of ground shaking the maximum accelerations, velocities and displacements imposed on various elements of a structure. The ground shaking can result in deformations of the ground that cause damage. One example is landslides in sloping ground. Another is relative movement along and across surface fault lines and uplift, each of which can be up to several meters. For example, the Hawke's Bay earthquake of 1931 caused nearly 2 meters of permanent uplift a Napier. The Time History Response of a structure is simply the response (motion or force) of the structure evaluated as a function of time including inertial effects. The time history analysis is the advanced level of Visual Analysis. There are computational advantages in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode using smooth design spectra that are the average of several earthquake motions.

In this work, it is proposed to carry out Response spectrum for irregular building greater than 90m in height in Zones II, III, IV and V. In present case Response spectrum analysis is performed and the results are compared in four different zones with 7m 4 bay length. The results of the analyses, in terms of lateral deformations, respective storey drifts and base shears are obtained and the conclusions are drawn.

Key words: Base Shear, deflection, storey drift, Bending moment, Shear force, Stability of indices and cost analysis.

1. INTRODUCTION

Mankind has always had a fascination for height and throughout our history; we have constantly sought to metaphorically reach for the stars. From ancient pyramids to today's modern skyscraper of the World, a civilization's power and wealth has been repeatedly expressed through the spectacular and monumental structures. The symbol of economic power and leadership is the skyscraper in the world.

This quest for height has laid out incredible opportunities for the building profession. From the early moment and shear frames to today's ultra-efficient highly mega-braced structures, the structural engineering profession has come to a long way of the structure. The design of skyscrapers is usually governed by the lateral loads imposed loads on the structure. As buildings have taller and narrower, the structural engineer has been increasingly challenged to meet the imposed drift requirements while minimizing the architectural impact of the structure. In response to this challenge, the profession has proposed a multitude of lateral schemes that are now in tall buildings across the World.

This study will be seeks to understand the evolution of the different lateral systems that have emerged and its associated structural behavior, for each lateral scheme examined, its advantages and disadvantages will be looked at.

Engineering Seismology

Seismology is the study of the generation, recording and propagation of elastic waves in the earth. An earthquake is a sudden movement of the earth's crust, which originates shock waves and dynamic waves caused by nuclear tests, man-made explosions etc. About 90% of all earthquakes results from the primarily movements on the effects. The remaining is related to collapse of sub terranean cavities or man-made effects.

The epicenters of earthquakes are not randomly distributed over the earth's crest. The epicenters of 99% earthquakes are distributed to along narrow zones of interpolate seismic activity. The remainder is considered to be aseismic. According to the theory of plate tectonics, the outermost layer of the earth, known as lithosphere, is broken into numerous segments or plates. The crust and uppermost mantle down to depth of about 70-100 Km under the deep ocean basins and 100-50 km under continents is rigid, forming a hard outer shell called the lithosphere. Beneath the lithosphere lies the asthenospehere, which is viscous in nature, a layer in which seismic velocities often decreases, suggesting lower rigidity. It is about 150km thick; it plays an important role in plate tectonics, because it makes possible the relative motion of the overlying lithosphere plates.

2. STRUCTURAL SYSTEM

The development of structural systems for tall buildings can be traced back to William LeBaron Jenny, in 1885. This combined with the invention of a safe passenger elevator by Otis in 1854 led to an explosion of high-rise buildings. In the ensuring 28-year period from 1885 to 1913, the first generation of skyscrapers culminated with the erection of Chrysler Building in New York in 1930, immediately followed by the Empire State Building in 1931, which held the record as the world's tallest building for 41 years.

The second wave of tall buildings began in 1956 based on new building technology and new concepts in structural design, climaxing in 1974 with the completion of Sears Tower, a 110-storey, 1450-ft tall building in Chicago. Following the Sears Tower, the post second generation of super tall buildings has included only "mixed" construction, consisting of both steel and reinforced concrete. The 1476-ft Petronas Towers, built in Kuala Lampur, Malaysia in 1997, and the 1667-ft tall Taipei 101 building, which attained its full height in Oct'03.

3. TYPES OF BRACES

Braced frames may be grouped into two categories, as either concentric frames (CBF) or eccentric braced frames (EBF), depending on their geometric characteristics. In CBFs, the axes of all members – i.e., columns, beams and braces – intersects at a common point such that the member forces are axial. EBFs utilize axis offsets to deliberately introduce flexure and shear into framing beams. The primary goal is to increase ductility. The CBFs can be configured in various forms, some of which are shown in Fig 3.8. Depending on the magnitude of force, length, required stiffness, and clearances, the diagonal member can be made of double angles, channels, T-sections, tubes or wide flange shapes. Besides performance, the shape of the diagonal is often based on connection considerations. The least objectional locations for braces are around service cores and elevators, where frame diagonals may be enclosed within permanent walls. The braces can be jointed together to form a closed or partially closed three-dimensional cell for effectively resisting torsional loads.

4. METHODOLOGY

In this study an office building of 35 storey having same plan in different types of zones (as per IS 1893 (Part I): 2002) is taken. The tall building in different zones is consider to study the effect of lateral deflection, storey drifts, Stability of indices, bending moment, shear force and axial force caused due to lateral load. I.e. due to quake load dynamic.

Building Dimensions: The building is 28m x 28m in plan with columns spaced at7m from center to center. A floor to floor height of 3.0m is assumed. The location of the building is assumed to be at different zones. An elevation and plan view of a typical structure is shown in fig. 5.1 (a) and 5.1 (b).

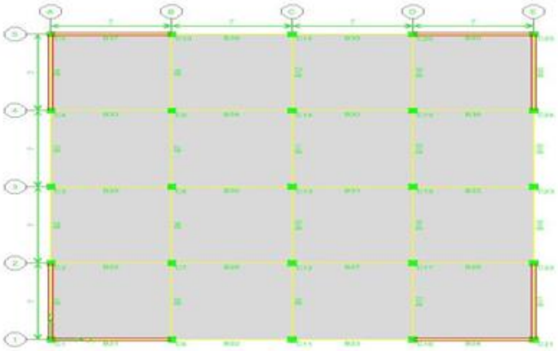
Size of Structural Members:

Column Size: 800 mm X 800 mm

Beam Size: 350 mm X 450 mm

Slab Thickness: 115 mm

Grade of Concrete and Steel: M20; Fe 415 Steel



Building plan dimension (Common to all floors, all models; units 'm')

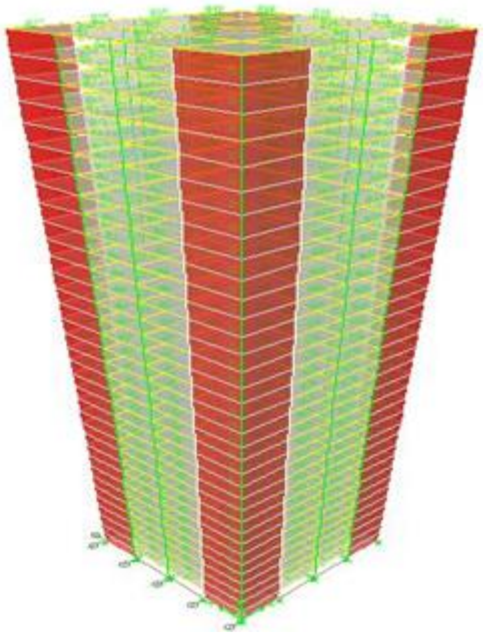


Fig 1 : 35 Storey Building 3D views

5. RESULTS AND DISSCUSION

Gravity Load calculations

Unit load calculations

Assumed sizes of beam and column sections are:

Columns: 800 x 800 mm at all typical floors

Area, A = 0.64 m^2, I = 0.02265m^4

Main beams: 350 x 450 mm at all floors

Area, A = 0.157 m^2, I = 0.00265m^4

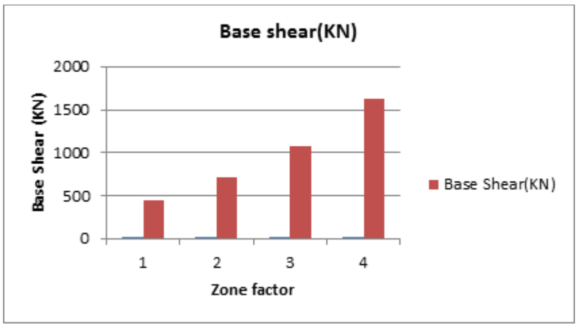
Member self- weights:

Columns (800 x 800) 0.80 x 0.80 x 25 = 16 kN/m

Main beams (350 x 450) 0.350 x 0.450 x 25 = 3.93 kN/m

Slab (115 mm thick) 0.115 x 25 = 2.87 kN/m2

Base shears with respect all zone factors:



Base shears with respect to Zone factors

Table 5.1 Base shears with respect all zone factors:

Zone	Zone factor	Base Shear(KN)
II	0.10	453
III	0.16	721
IV	0.24	1081
V	0.36	1630

Design Seismic Load

The infill walls in upper floors may contain large openings, although the solid walls are considered in load calculations. Therefore, fundamental time period T is obtained by using the following formula:

Ta = 0.075 $h^{0.75}$ [IS 1893 (Part 1):2002, Clause 7.6.1]

= 0.075 x (105)0.75 = 2.46 sec.

Zone factor, Z = 0.16 for Zone III IS: 1893 (Part 1):2002, Table 2

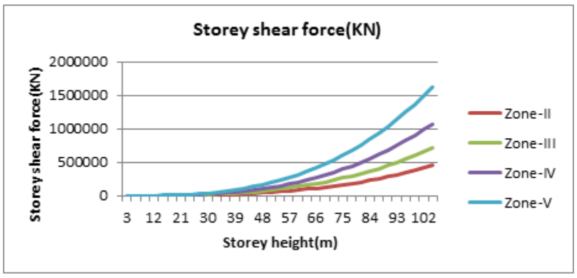
Importance factor, I = 1.0 (other building)

Medium soil site and 5% damping

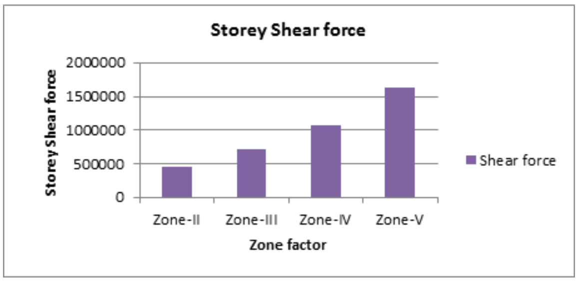
S_a/g=1.36/2.46 =0.5528

Table: 5.2 showing Storey Shear force (V_i) values for different zones

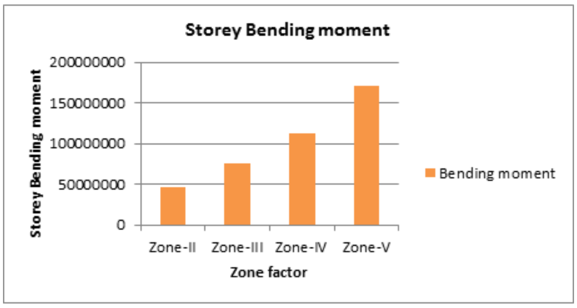
S .No	Storey Height (m)	Storey Shear force(V_i) KN			
		Zone-II	Zone-III	Zone-IV	Zone-V
1	3	30	48	72	108
2	6	151	241	361	988
3	9	251	641	1011	1988
4	12	731	1351	2161	3688
5	15	1481	2551	3971	6388
6	18	2481	4251	6571	10388
7	21	3961	6551	10121	15688
8	24	5961	9551	14721	22688
9	27	8421	13551	20521	31488
10	30	11421	18551	27721	42488
11	33	15021	24551	36491	55708
12	36	19321	31551	46921	71408
13	39	24421	39651	59141	89808
14	42	30421	49151	73341	111208
15	45	37221	59951	89641	135708
16	48	44921	72251	108141	163708
17	51	53621	86251	129141	195208
18	54	63421	101901	152541	230608
19	57	74421	119401	178641	270608
20	60	86571	138731	207641	314608
21	63	99901	160031	239641	362808
22	66	114601	183031	274641	415808
23	69	130601	208581	312941	473808
24	72	148101	236581	353941	536808
25	75	167101	266801	398941	604808
26	78	187601	299401	447941	678808
27	81	209601	334601	500941	758808
28	84	233401	372601	557941	843808
29	87	258901	413201	618841	935808
30	90	286201	456701	683841	1033808
31	93	315201	503201	753841	1138808
32	96	346201	553201	827841	1250808
33	99	379201	605861	906841	1369808
34	102	414201	661861	990841	1495808
35	105	451401	720861	1079841	1629808



Graph 5.1 Storey shear force for all zones for 35 Storey Building in Soil Type II.



Graph 5.2 Storey shear force for all zones for 35 Storey Building in Soil Type II.



Graph: 5.3 Storey bending moment for all zones for 35 Storey Building in Soil Type II.

Stability Indices

It is necessary to check the stability indices as per Annex E of IS 456:2000 for all storey's to classify the columns in a given storey as non-sway or sway columns. Using data from Table 1 and Table 4, the stability indices are evaluated as shown in Table. The stability index Qsi of a storey is given be

$Q_{si} = (\Sigma P_u \, \Delta_u)/ (H_u h_u)$

Where

Qsi = stability index of ith storey

ΣP_u = sum of axial loads on all columns in the ith storey

Δu = elastically computed first order lateral deflection

Hu = total lateral force acting within the storey

hs = height of the storey.

As per IS 456:2000, the column is classified as non-sway Qsi ≤0.04, otherwise, it is a sway column. It may be noted that both sway and non sway columns are un braced columns. For braced columns = 0.

Zone-II:

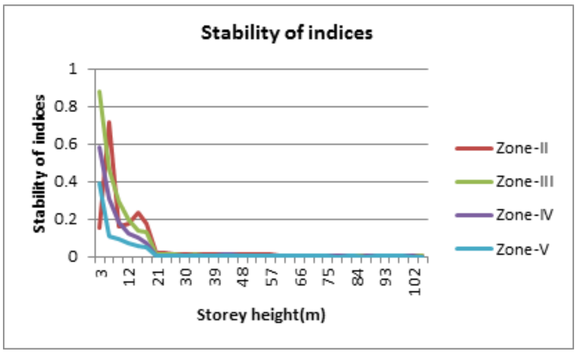
Stability of indices of first storey

$Q_{si} = (\Sigma P_u \, \Delta_u)/ (H_u h_s)$

$=2341 \times 0.006/30 \times 3$

$=0.155$

Similarly Zone-IV and V Respectively.



Graph: 5.4 Stability of indices for all zones for 35 Storey Building in Soil Type II.

6. CONCLUSIONS

Based on the study of the "Seismic analysis of tall building for different earthquake zones" the obtained results were analyzed and the following conclusions are drawn

1. The structural performance based on displacement values for dynamic loading is 26% more for Zone-V, when compared with zone-II.
2. Similarly for based on the storey drift the performance for dynamic loading is 51% more for Zone-V, when compared with zone-II and for other Zones(III &IV) .these values are 24% more and 20% more when compared with zone-II.
3. When compared with zone II the base shear value is 37% more in zone V for dynamic loading and for other Zones (III &IV) These values are 58% more and 72% more when compared with zone-II.
4. The structural performance of the building is good in zone II. Among the other three zones. When compared with zone II the Stability of indices value is 170% more in Zone-V for dynamic loading.
5. The Storey torsion moment value is 72% more in zone-V, when compared with zone-II and for other Zones (III &IV) these values

are 24% more and 20% more when compared with zone-II.

6. Similarly for based on the Storey shear force the performance for dynamic loading is 72% more for Zone-V, when compared with zone-II.
7. When compared with zone II the Storey bending moment value is 93% more in zone V for dynamic loading and for other Zones (III &IV) These values are 58% more and 37% more when compared with zone-II.
8. The cost of the critical member value is 10% more in zone-V, when compared with zone-II and for other Zones (III &IV) these values are 7% more and 3% more when compared with zone-II.

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