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Impact of Gust and Tectonic Drags on Irregular High Rise Structures

Naved Ahmed, Rajeev Banerjee

***Abstract:** As the population is growing and land becomes limited and new materials and construction technologies are built together, structural structures of this nature are growing larger and smaller, which are prone to two types of dynamic forces, tectonic drags and wind powers. In developing countries like India the exponential growth of the urban population has prompted a reassessment of the value of high – rise irregular buildings. For the construction of high - rise irregular buildings, the impact of gust loads is to be remembered. In India, gust caused numerous structural failures. IS 875:2015 Part-3 considers the gust loads on various kinds of irregular structures and IS 1893 (Part-1):2016 recognizes tectonic drags. The study focuses on peculiar constructions of different aspect ratios i.e. the impact of tears and tectonic drags. H / B ratio, with H being the overall construction system height; and B being the base width of the structure frame using STADD , Structure mass irregularities using E-TABS; from this paper we are examining the impact of wind (gusts), seismic (tectonical) load on building height by changing the number of floors with a the aspect rate. H / B ratio Many researchers design a system that is immune to tectonic drags, but the tectonic drag framework can not be built without causing damage. A large proportion of existing urban infrastructure is composed of vertical irregular structures.*

***Keywords:** High-rise structures, Wind / Gust effects, Tectonic Drags effects, E-tabs.*

I. INTRODUCTION

A. General

Due to increasing population and scarcity of land available for construction coupled with development of modern materials and construction techniques structures are getting taller bigger and lighter this kind of structures are vulnerable to two types of dynamic forces that is tectonic drags and wind forces. Wind is the motion of air relative to the earth's surface. The design of a large structure is critical in view of the dynamic nature of the gust, and varies with time and space due to the unpredictable nature of the gust, while gust is a positive or negative departure of wind speed from its mean value, lasting not more than 2 minutes over a specified interval of time. The load of the gust depends on the landscape and the geology of the area, as well as the existence of the climate, size, shape and physical characteristic of the system. It is really necessary to take in account the fluctuation nature of wind while designing a building.

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Tectonic drags are the most devastating and destructive of all the natural calamities. Tectonic drags are distinctive shaking of the earth surface which results in damage of the structure and causes several hundreds of casualties or loss of life. The tectonic drags are caused due to the energy released at the moment of faulty rocks. There will be continuous movement of the rock. The tectonic drags occurred in the past days proves that effect on the building structures, loss of human lives, damage on the ancient structures, flyovers bridges etc. this will directly affect the growth of the country. Many researchers are carried out to design a tectonic drags resistant structure but still it is not been possible to design the tectonic drags resistant structure without causing damage. Vertical irregular structures constitute a large portion of the modern urban infrastructure**.**

B. Concept Of High-Rise Building

The internal structure consists of walls , floors, roofs and screens. A big structure is a multi-storeyed structure in which most people rely on lifts to access one's destination. The high-rise towers are the most prominent. The National Structure Code 2005 from India states that "A building with more than 50 meters in height is referred to as a high-rise structure".

Types of structures

- **a) High-Rise Structures -** A building with a height more than or equal to 50m or having a height to smaller dimension more than 6.
- b) **Skyscrapers-** Buildings taller than 150 m (492 feet) are classified as sky-scrapers. Most American style skyscrapers have a steel frame, while residential tower blocks are usually constructed out of concrete.
- **c) Tall structures-** Buildings between 23 m to 150 m (75 feet and 491 feet) high are considered Tall structures. The structures are high & lead to higher vertical loads and higher lateral loads (mainly due to wind stress) in comparison with lower buildings. The materials used for the structural system of high-rise tall buildings are reinforced concrete and steel.
- d) **Regular Tall Structures-** The regular high-rise structures are those whose structural eccentricity, coincide of center of mass with the center of stiffness.
- *e)* **Irregular Tall Structures-** The irregular high-rise structure are those in which there is a irregular distribution in their mass, strength and stiffness along the height of building. The analysis and design of buildings constructed in high seismic zones, have the primary objective to ensure that the building has enough ductility to withstand the earthquake forces.

List of High -Rise Structures in World

S.N.	Name	Places	Height (mt)	Year
1	Philadelphia City-hall,	New York,	167,	1901,
2	Singer Building,	New York,	187,	1908,
3	MetLife Tower,	New York,	213,	1909,
4	Woolworth Building,	New York,	241,	1913,
5	Bank of Manhattan Trust,	New York,	283,	1930,
6	Chrysler Building,	New York,	319,	1930,
7	Empire State Building,	New York,	381,	1931,
8	World Trade Centre,	New York,	417,	1971,
9	Sears Tower ,	Chicago,	442,	1973,
10	Petronas Tower,	Kuala-Lumpur,	452,	1998,
11	Taipei 101,	Taipei,	508,	2004,
12	Burj Khalifa,	Dubai,	828,	2010,
13	Jeddah Tower,	Jeddah,	1008,	2021,
14	Dubai Creek Tower.	Dubai.	1345	2022

II. METHODOLOGY

A. Wind Analysis Using Is 875 (Part III): 2015

i) Wind Evaluation Method

1.1 Design Wind Speed (Vz)

The basic wind speed for any site shall be obtained from Figure 1 in IS 875: Part 3- 2015. Basic wind speed can be mathematically expressed as follows:

$$V_z = V_b \times k_1 \times k_2 \times k_3 \times k_4$$

1.2. Basic Wind Speed (V_b)

Figure gives Indian simple wind speed diagram, as relevant for different regions of India at lam heights above average ground level.

1.3. Risk Coefficient (k1)

For All General Buildings and Structures with general design Life as 50 years and For Basic Wind Speed as 47 m/sec k_1 from Table can be calculated as 1

Therefore (k) = 1

(Refer Table No. 1 from IS 875: Part 3- 2015)

1.4. Terrain and Height Factor (k2)

Terrain— Selecting types of terrain may rely on the impact of barriers that roughen the earth's surface. The type of terrain can differ depending on the wind direction. The alignment of any system can be properly planned in keeping with the environmental information available about the wind direction.[9]. (Refer clause no 6.3.2.1 from IS 875: Part 3- 2015)

1.5. Topography (k3 factor)

The standard V_b wind speed takes the total site height above sea level into account. This does not allow local topographical features such as hills that significantly affect wind speeds around them.. The value of k3 can be found to vary from level above ground to level near the ground and to 1,0 on levels higher. (IS 875: Section 3- 2015 comparison clause 6.3.3)

1.6. Importance Factor for Cyclonic Region (k4):

In severe cyclones, India's east coast is relatively vulnerable. Gujarat is most affected by serious cyclones on the western coast. An analysis of gust velocity and building damage and structure damage indicated that during the cyclones, the speeds indicated in the basic wind speed map are often exceeded[9]. (IS 875: Part 3-2015 reference clause No 6.3.4)

1.7. Calculation of Pressure Coefficient

Pressure coefficients are estimated, refer clause no 7.3 from IS 875: Part 3- 2015.

$$F=(C_{pe}-C_{pi})A.p_d$$

Where

C_{pe}=external surface coefficient,

C_{pi}=internal surface coefficient,

A=surface area of structural element or cladding unit, and

P_d=design wind pressure

ii) Gust Effectiveness Factor (GEF) Method

Use current rafter models, knowledge of the highest wind speeds multiplied over an hour at a given location is important. Mean average hurricane velocities at varying heights is given in Table 33 of IS: 875 (Part) – 1987.

The difference of the hourly average gust velocity with the altitude shall be calculated by using the following:

$$V_z' = V_b * k_1 * k_2' * k_3$$

Where,

V_z'= hourly mean wind speed m/s at height z;

V_b= regional basic wind speed in m/s (figure. 1 of IS: 875 (Part 3) – 1987);

k_1= probability factor (risk coefficient) (clause. 5.3.1 of IS 875 (Part 3) – 1987);

k_2'= terrain and height factor (Table. 33 of IS- 875 (Part 3) – 1987);

k_3= topography factor (clause. 5.3.3 of IS-875 (Part 3) – 1987);

Along wind load on a structure on a strip area (Ae) at any given height z is given by:

$$Fz = Cf * Ae * Pz' * G$$

Where,

Fz= along wind load on the structure at any height z corresponding to strip area Ae;

Cf= force coefficient for the building;

Ae= effective frontal area considered for the structure at height z;

Pz'= design pressure at height z due to hourly mean wind obtained as 0.6 $Vz'2$(N/m2)

G= gust factor (=$peak\ load/mean\ load$), and is given by

$$G = 1 + gfr \sqrt{[B(1+\emptyset)2 + SE\beta]}$$

Where,

gf= Peak factor described as the ratio between the predicted maximum point value and the average square root value of the variable force.;

r= roughness factor which is dependent on the size of the structure in relation to the ground roughness;

The value of 'gfr' is obtained from (IS 878 PART-3)

B= Information factor which suggests and is estimated from a measure of a slowly varying gust load component (IS PART-3);

$SE\beta$= measure of the resonant component of the fluctuating wind load;

S= Factor of size reduction (IS 875 PART-3);

E= Evaluation of the energy available on the flow field at the natural structure frequency obtained from (IS 875 PART-3);

β= coefficient of damping (as critical damping fraction) of the building;

$\emptyset$= $gfr\ \sqrt{B4}$ and Is always to be planned only for buildings less than 75 m height in topography Category 4 and for buildings less than 25m height in terrain category 3 and is to be taken as zero in all other cases;

Vh= Vz= hourly mean wind speed at height "z".

B. Seismological Evaluation Utilising IS-1893 (Part I): 2016

i) Linear Static Method

The linear static procedure estimates the lateral loads according to the basic structural cycle and applies them at each floor level to the architecture center of mass. The size of these pseudo lateral loads was selected to result in the design displacement expected during the earthquake design when applied to the linear elastic model of the building.

Linear Static Assessment Steps are as follows:

1.1. Design Horizontal Seismic Design coefficient (Ah)

The concept description of a horizontal earthquake co - efficient (Ah) shall be as follows: (Reference IS 1893: Part I-2016)

yvm

$$A_h = \frac{ZISa}{2Rg}$$

1.2. Basic natural period (T)

For a resistant structure without brick panels, empirical expression can be estimated for the approximate basic natural period of vibration (T) in seconds:

$$T = 0.075h^{0.75} \text{sec for RCC frame building}$$

$$T = 0.085h^{0.75} \text{sec for steel frame building}$$

Where, h= Height of building in m.

The calculated natural vibration duration (T) in seconds can be determined by the analytical term for all other constructions including moment - resistant frame buildings with brick infill panels.

$$T = 0.009h/d^{0.5}$$

Where,

h = Height of building in m.

d = Lateral Dimension of Building

1.3. Seismic Weight

The seismic load of each floor and the appropriate amount of the imposed load are taken as its complete dead load. The earthquake weight of every floor is calculated by equal distribution in any floor above and below that floor of the walls and columns.

The seismic building weight is the amount of all floor's seismic weight.

1.4. Importance factor

The structures are given an important factor in terms of the structure's functional use, characterized by its dangerous consequences and post - earthquake requirements etc[10]. (See IS 1893 Table 8: Section I-2016) Table 8

1.5. Factor for Response Reduction

The system can create a factor called response reducing factors, which concentrate on ductile or fragile deformation, depending on the perceived tectonic damage performance.(Refer Table No. 9 from IS 1893: Part I- 2016)

1.6. Modelling of Seismic Base Shear

The total design lateral forces or the design base shear (Vb) along any principal direction shall
be determined by the following expression:

$$V_b = A_h.W$$

5.1.1.7. *Spread of Base Shear*

The sub - base shear (V_b) estimated by the calculation above shall be given in accordance with the following expression along the storey height.

$$Q_i = \left(\frac{w_i h_i^2}{\sum_{j=1}^{n} w_j h_j^2} \right) V_B$$

III. LITERATURE REVIEW

1. Fazia Ali-Toudert, Helmut Mayer. (2006)

Analysis of the contribution to developing a comfortable microclimate for pedestrians at street level through street design design , i.e. aspect ratio (or height-to-width, H / W ratio), and solar orientation.

The investigation is done using the ENVI-met 3D numerical model, which simulates high spatial and temporal resolution of microclimate changes in urban area.

Calculations of model models was carried out on a typical summer day in the hot and dry regions Ghardaia (Algéria) (32.401N, 3.801E and 469ma.s.l.). Symmetric urban canyons were investigated, with various ratios from height to width (i.e. H / W 1⁄4 0.5 , 1, 2 and 4) and various sun orientations (i.e. E-W, N-S, NE-SW and NW – SE). The emphasis is placed on the use of the physiologically equivalent temperature (PET) to make the human biometeorological assessment of these microclimates. The results demonstrate competing thermal comfort patterns between deep and shallow urban streets as well as between different directions. The time and time of the day during which the extreme warm tension and the spatial distribution of PETs on street level was strongly dependent on the aspect ratio and street orientation are shown in both case studies. This is important because it directly affects the design options regarding street usage, e.g. roads designed solely for public use or motor traffic, and also the time to travel through urban spaces. If properly combined, both urban factors examined can mitigate extreme heat stress. Indoor solar exposure was narrowly considered as an additional requirement for street design by including winter solar power needs.

2. Vindeffekter (2007)

They explain the first natural frequency calculation of high - rise buildings, the acceleration of the wind induced in high - rise buildings and how the acceleration comfort criteria in high - rise buildings affect human building bodies. The most important results were that in the top floors of Turning Torso there is excessive movement, so that sensitive people can see movement and movement of hanging items. The objective was to create a certificate that can be applied in practice, which can guide the design of high - ranking buildings in the early stages of the development due to the wind impact.

3. N. Lakshmanana, S. G. Nayagam, P. H. krishna, A. Abrahama and S. C. Ganapathi, 2009,

There have been recorded Long - lasting information on wind speeds at Seventy Indian meteorology facilities. The annual maximum wind speed (KMP) for each site was processed for daily taste data. The intensive value quantiles have been derived using the Gumbel probability paper approach. A wind speed modeling foundation for each site was also tested for a return period of 50 years. Changes to wind speeds are highlighted and revisions to the map will be suggested The climate region chart of constructions / systems.

4. M.R.Wakchaure (2012)

Carried out seismic & wind analysis of35 and 39 storied buildings having dual systems & plan irregular shapes like T & oval shape by using ETABS software & IS:1893(Part-1)-2002. The analysis was done by taking into account factors such as time period, frequency modal mass participating ratios &displacement.

It has been concluded that dual system is better solution to overcome the effects produced by plan irregularities.

5. Y. A. Vyavahare, P. N. Godbole., N. Trupti, 2012,

As an artist, high buildings are flexible slim systems of their kind, which must be studied to assess the importance of wind speed causing arousal along and across the wind path in a particular area. Indian codal provision of wind load practice for all buildings and structures is the procedure used to identify the wind response of large structures along the lines of the IS-875 Part-3, 1987, and the gust reaction and interference impact are presently not protected by the codes. IIT Kanpur laid out the following article: ' Review of Indian Wind Code IS 875 (Part 3) 1987 ' under GSDMA Project, provides recommendations on wind reactions of the high buildings and structures according to the process of the Australian / New Zealand ' Structural Design Acts Part 2 Wind Action ' standard. This paper uses the Artificial Neural Network (ANN) to generalize the above-mentioned procedure from the limited available data, so that a design with a given (h:b:d) ratio can obtain a wind response.

6. Jalal Mushina Obeed (2013)

Carried out the seismic analysis & wind analysis of 50 storey T shaped irregular building located in zone V and by using E-tabs software. Wind load analysis was done by gust factor method and seismic analysis was done by response spectrum method. The analysis was done by taking into account factors such as shear force, base shear, torsion, bending moment & displacement. It has been concluded that shear force and torsional moment are higher in case of irregular building compared to regular building and bending moments in regular buildings are higher compared to irregular building. The displacement of irregular building is more as compared to regular building under wind loads. The displacement in irregular is less compared to regular building under seismic loads.

7. Kiran Kamath, Shruthi (2013)

It describes how the seismic performance of steel frame structures with and hone infills are affected by different aspect ratios. The building's height is kept constant here, with different base widths. For the study two types of frames are considered, one with the same steel sections. ETABS is used for study and for evaluation of the reference of pushover curves and strength points of frames with different aspects ratios. The presence of infill stiffness has been shown to make a significant contribution to structural performance compared to the bare frame.

8. Abhay Guleria. (2014)

ETABS calls for Extended 3D Building Systems Analysis. Skyscrapers, car park garages, steel and concrete frameworks, lower and high - speed buildings and portal system systems are widely used to be examined by ETABS. This paper focuses primarily on the structural behavior of multi - story buildings for various design configuration, such as rectangular shapes, C, L and I. The R.C.C. constructed building simulation of 15 floors is conducted on the ETABS analysis software. The system is calculated and compared for all analyzed cases after study, maximum shearstrength, bending moments and maximum shield displacement.

9. Ramesh Konakalla (2014)

Carried out the seismic & 20-story wind study of specific plan shapes like square, L, inverted U & T shape by using linear static analysis &STAAD Pro software. For linear static analysis IS 1893 (part-1):2002 was used & for wind analysis ASCE-7: 02 code was used. The comparison has been done in terms of storey drift & lateral displacement. It has been concluded that in the regular frame, there is no torsional effect in the frame because of symmetry. In case of irregular structure responses are different for the columns located in the plane perpendicular to the force action. For U plan shape the responses in the corner columns of two limbs are same in the earthquake loads but different in wind loads.

10. K.R.C. Reddy (2015)

The chimney has its own importance in various type of high - rise structures. This document offers wind analytics of high-vibration reinforced concrete chimneys and strategies of codal of India (IS 4998 (part 1)), American codal (ACI 307) and Australia code (AS / NZS (1170.2)). The RC chimney is a multi-degree liberty system that is subject to statistical load because of the mean speed of the wind and dynamic force due to the changing part of speed, for the analysis based on the case-case vibratory approach. As temporary random process, the changable part of wind speed at a time is very careful. The long-term analysis procedures of tall Indian, American and Australian RC chimneys are then analyzed in the long-wind analysis . In order to get their responses, four RC chimneys are analyzed using this method. The codal methods of an analysis of long winds were found to be essential, and not ready to estimate chimney deflection and to produce mixed results. These codes discuss simplifying assumptions.

11. K. Vishnu Haritha, Dr. I. Yamini Srivallie (2015)

Depending on the location of the system, structure height, the wind effects are prevailing. In addition, their paper discussed the equivalent static approach used in wind load analysis for buildings with a particular aspect ratio. By changing the number of bays, the aspect ratio can be changed. For this analysis, the aspect ratio 1 , 2 , 3 was considered using design software.

12. A. Rajman, Prof P. Guha (2015)

On this paper were studied 4 distinct structures, namely round, rectangular, square and triangular.. They also describe in their research paper the concept, operating conditions and aspects of side load for big structures. They then concluded with an interpretation of various shaped buildings and various building stories. Finally, they result in a high elevation building which, under various conditions and areas, is most stable.

13. Anupam Rajmani (2015)

Carried out seismic analysis and wind analysis of 15, 30 and 45 storeys building with circular, rectangular, square and triangle plan shape using STAAD-Pro software. The comparison was made by taking into account these parameters as wind load, earthquake load, and node displacement.

It has been concluded for maximum tectonic drag and maximum gust forces for 15 floor structures respectively, the circular form and triangular shape is most stable.
For 30 stories, the rectangular shape for maximum earthquake and wind loads is most stable.
The circular shape & rectangular type of the 45 story building is most suitable for optimum tectonic and gust load respectively.

14. Md. Mahmud Sazzad (2015)

Carried out the seismic & gust analysis of six storey structure with three non-common plan shapes i.e. rectangular with hollow space, modified cross shaped& L-shaped by using computer aided analysis & Bangladesh National Building Code (BNBC), 2006.
The analysis was done by taking into account factors such as base shear, displacement and storey drift.
It was done that rectangular with hollow space model is safest considering all the conditions &shape of building has noticeable effect in minimizing the drift of building.

15. Veena S. Ravi (2016)

Carried out the seismic analysis of G+11 storey building for zone II & V having seven different plan shapes with one regular plan and remaining irregular plan i.e. C, E, H, L, T, PLUS shapes with the help of STAAD-Pro software and IS-1893- 2002-Part-1.
Response spectrum analysis method was used for analysis. The comparison was made by taking into account these parameters design lateral shear, time period, joint displacement. It has been concluded that regular square plan building have maximum base shear value whereas L shape building have the least value zone II & V.
Frequency & displacement is maximum in L shaped building. Irregular shaped buildings undergo maximum displacement than regular buildings during earthquake.

16. Akash S. Waghmode (2016)

Carried out the wind analysis of G+15 shear wall structure with J shape and rectangular shape using Etabs 2015 software &IS 875:1987 (part 3). Shear walls were provided at all corners in L shape. The comparison was made by taking into account these parameters storey displacement & storey drift. It has been concluded that displacement and drift in J shape is more so need to be analyzed to minimize the wind load & rectangular structure in wind prone zone is preferred.

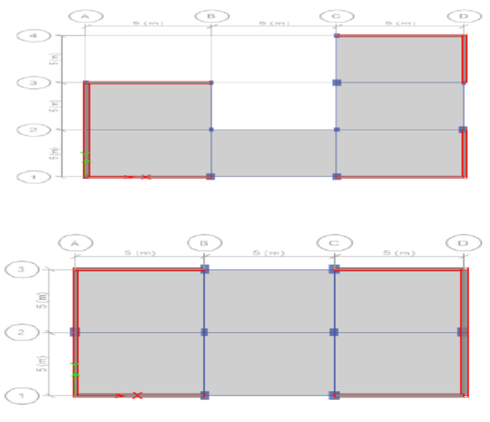

Figure.9.Plan View J shape and Rectangular shape buildings

17. Megha Kalra (2016)

Carried out wind analysis of 50 storied building having different plan shapes such as rectangular, L, U, T, I, Plus and non-uniform shape by using STAAD Pro software &IS 875-Part III. The comparison was made by taking into account these parameters storey drift, joint displacement, intensity & bending moment. It was finalized that to be L-shape and U-shape.

18. Naveen. G.M . (2016)

Carried out seismic analysis of 10 storey RC frame building with regular & irregular plan shape by response spectrum method using ETABS 2015 and IS Code 1893:2002 (part 1). Three models with one regular & two irregular were considered for study. All models have different shape but having same area. The comparison was made by taking into account these parameters such as maximum storey displacement, storey drift, storey stiffness, periods and frequencies of modes during earthquake. It has been concluded that irregular shape building have the higher frequency. Storey-drifts are on peak in regular form building in contrast with irregular buildings. If the buildings Greater length in the seismic motion direction are having greater length in the direction of earthquake motion then are affected more. Storey shear in the irregular building structure is higher as compared to regular structure.

19. Alhamd Farqaleet (2016)

Carried out the dynamic analysis of ten storey RCC building frame rectangular in planning nonlinear time history analysis method in SAP 2000. The analysis was done by taking into account factors such as base shear, storey drift, and storey displacements. It is accomplished that storey drift increases from base to top floor. The maximum drift obtained for a ten-storey building was within the permissible limits.

20. D. R. Deshmukh, A. K. Yadav (2016)

They illustrate structures of high - rise, which require longer time to use conventional manual methods, and complicated calculations. In addition, the program was used, offers a quick, effective, handy and to the point framework of structure analysis and design. It’s principle is to analyse and model, with the software STAAD-Pro, a multi - story G+19 (three - dimensional frames). The Design requires STAAD Pro to analyse the entire structure. In the STAAD-Pro research, the design methods are confined state-designed in compliance with Indian Standard Practice Code. They conclude that STAAD-PRO is an incredibly potent tool that saves time and precision in design.

21. Shaikh Muffassir ,L.G. Kalurkar , (2016)

This study shows that the structure of the high elevation or building is an urban metro prerequisite. The multi-story, elevated RC building is broader and less resilient as a judge of composite structures. This study explores the resemblance or contrast of RCC with the wind impact composites, as well as its composite structure with different plans.

A total of 15 building model numbers were arranged for this study with the use of ETABS 2015 tools for wind loading study. The different software is based on wind and earthquakes but we use ETABS 2015. Unlike 20 meters, 50 meters and 80 meters, the wind analysis is carried out. The detailed analysis illustrates the layout of the compound is greater in its elastic nature and is more vulnerable in comparison to the RCC structure. In software analysis, the entire study is examined. Moreover, the comparison of a different configuration of the plan shows the parameter response such as storey change, storey stiffness, core reflex, and gust period., is reactive. This is why the most efficient construction shape in horizontal zones has been concluded.

22. T. Gunawardena, S. Fernando, P. Mendis, B. Waduge, D. Hettiarachchi, 2017,

There is a growing population of urban habitats around the world which there is as much need for large buildings as ever. This is a reality that Sri Lanka is currently experiencing with the rapidly expanding skyline of Colombo with a large number of vibrant, emerging buildings. A critical design criterion is the reaction of high buildings to wind power and involves both conventional force-based designs and solutions driven on performance .

23. Sanjay Kumar Sadh, Dr. Umesh Pendharkar. (2016)

The behaviour, size and geometry of a building during earthquakes have been studied. The durable design of buildings depends on the strength, integrity and inelastic capacity of the building as large as possible to withstand a seismic activity. This is typically accomplished by selecting an appropriate building design and clearly identifying structural components. Configuration is important for seismic response in efficient buildings. Overall design, structural systems and load paths are critical aspects that affect the seismic structure of buildings. The slender building ratio and the building core size drive the efficient design. This paper deals with seismic analysis of multi - story RCC structures. Regular elevation and plan of the test structures. According to Aspect Ratios the height and the base dimensions of the buildings vary. Aspect ratios proportions are so allocated that different configurations are made available for templates for low , medium and high-level buildings. Four models of specific horizontal aspect ratios are present in this study. 1, 4,6 & 8 of different length Vertical Aspect ratios viz. 12 m. to 96 m. The RCC multi - story buildings were considered 1, 4, 6 & eight from 4, 16, 24 & 32 floors and their influence on the behavior was demonstrated with the parameters for the seismic design in line with IS-1893-2002-Part-1-3.

24. Aniket A. Kale (2017)

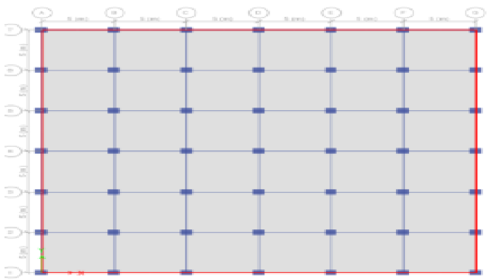

Figure.1. Square shape

Carried out the wind & seismic analysis 15, 30 & 45 storied buildings in four different shapes of the same region utilizing sophisticated CSI ETABS software. Response spectrum method was used to find the dynamics. Considering the parameters such as story displacement, story drift, base shear, overturning Moments Mz, acceleration & time period, the comparison was done. It was known that the building of 15-storey high-tectonic quake is most stable, and the structure of a 15-storey maximum gust triangle is morely durable. For 45-story circular and rectangular building, the most stable is for optimum tectonic drags and gusts impacts respectively. For building on 45 floors, gust effects are important and seismic on the other side is crucial for building on 15 floors and 30 floors. Compared to the tectonic one, the gust effect is more important.

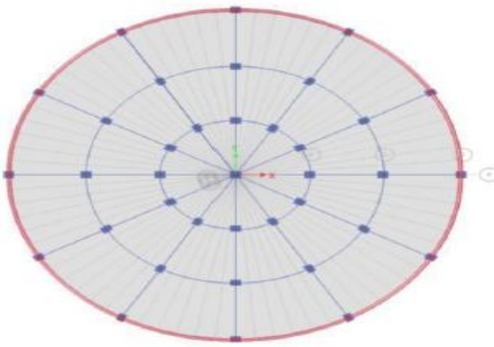

Figure.4.Circular Shape

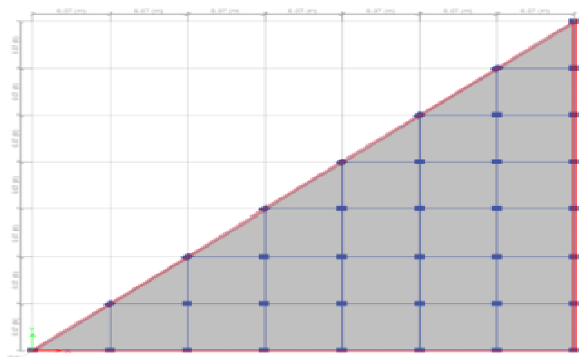

Figure.3 Triangular Shape

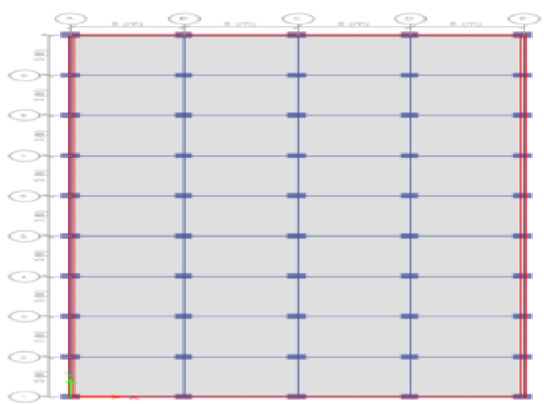

Figure.2. Rectangular shape

25. Mangesh S. Suravase (2017)

Performed seismic analysis on G+10 storied R.C frame buildings with different plan shapes such as square, H-shape, L-shape& rectangle with core.
Plan area & height of all building models were kept same. Seismic analysis was carried out by pushover analysis method in designing software.
The analysis was done by taking into account factors such as base force & monitored displacement.
It has been concluded that the regular building resist earthquake forces longer time and withstand for longer time.
Irregular building model shape-H & L is having less resistance to earth quake forces.
Irregular building model shape-O is having more resistance to earthquake than H & L shape building.

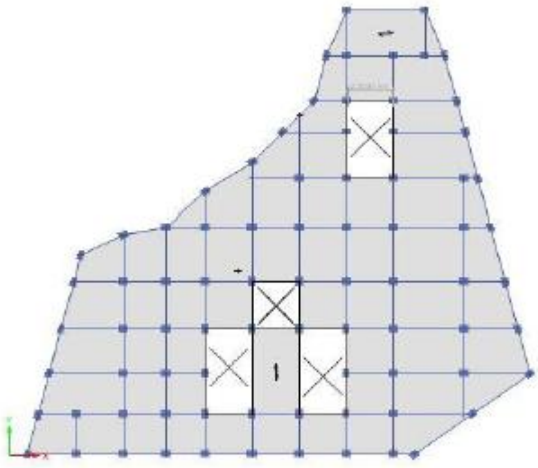

Figure.6.Models with irregular floor plan

26. Albert Philip (2017)

Carried out seismic analysis of G+12 storied reinforced concrete building with regular and irregular plan shape using CSI ETABS software for earthquake zone III in India. The analysis was carried out by adopting response spectrum analysis method.
The analysis was done by taking into account factors such as story displacements, story drifts, story shear and stiffness. It has been concluded that story displacement increases linearly with height of building.
Maximum storey drift occurred at second floor for irregular structure at fourth floor for regular structure.
Maximum storey shear force was observed between ground floor and second floor for regular structure and at ground floor for irregular structure.
Storey stiffness varies non - linearly for both the structures.

27. T. Prasanthi (2017)

Performed seismic analysis of G+20 storied RC building to study the structural behaviour of building for different plan configurations like rectangular and C- shape. Seismic analysis has been carried by static and response spectrum analysis by using ETABS computer program. The comparison has been done by considering the parameters such as structural displacements, drifts, story shear, overturning moment and stiffness. It is finalised that rectangular shape building has more stiffness than C shape building. The values of base shear and top storey displacement are higher in response spectrum analysis than in static analysis.

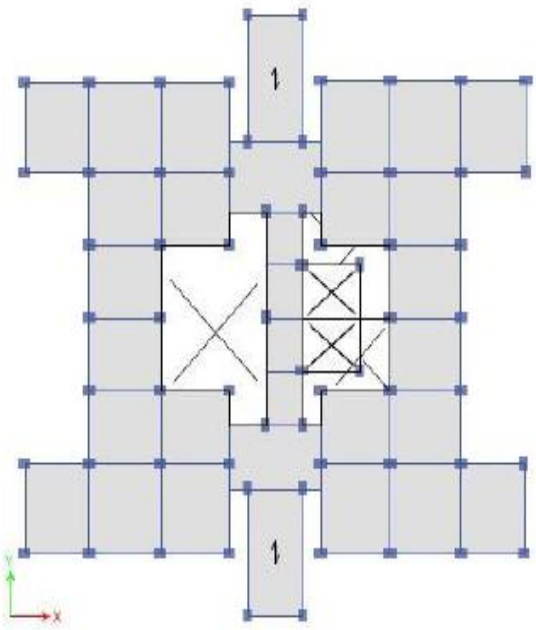

Figure.5. Models with Regular Floor Plan

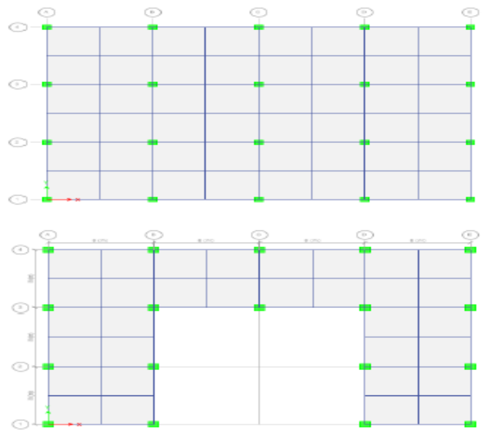

Figure.7.Plan of rectangular shape building & C-shape building

28. Narla Mohan (2017)

Performed seismic analysis & wind analysis on G+20 storey RC building square in shape with four different zones II, III, IV & V. The analysis was carried out by adopting using ETAB software adopting response spectrum analysis method& wind analysis as per IS 875-1987 part-III using ETABS software. The analysis of different bay lengths, four models were used. Various seismic zone factor values have been taken and the results interpreted for their subsequent impacts. The comparison was made by taking into account factors such as drift, insulation, torsional force and moving parameters. The inference is that the base change decreases as we go to higher seismic zones.

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The storey drift due to wind load is mainly occurred at the middle of the building structure. Storey Shear is decreased as height of the building increased and reduced at top floor in all the building models. Least stable of all the shapes. Plus shape and Non uniform are the most stable.

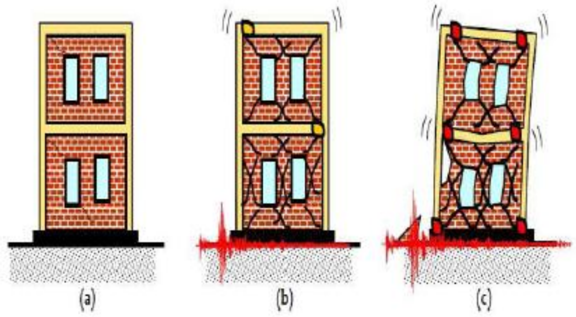

Figure.8. Earthquake-Resistant Design Philosophy for buildings

29. Rajiv Banerjee, J. B. Srivastava

In this paper, the optimum or suitable location of shear wall in a high rise irregular shaped building is determined. The criteria of choosing suitable location are well mentioned with suitable examples. We have tested several models in dynamic analysis with the help of ETABS ver. 16. Both Time History and Response Spectrum Methods are performed in the analysis. The paper clearly specifies the causes of torsion in a high rise building as well as it also specifies the ways in which we can control the torsion and storey displacement with the help of shear wall in the high-rise buildings.

30. Madan Singh, Rajiv Banerjee, Syed Aqeel Ahmad, Anwar Ahmad

Location of shear wall construction, is the combination of two materials i.e. reinforced concrete and structural steel used for the purpose of building yielding to behave together, increase safety and more economic without any damage to the aesthetic appearance, shear walls are more efficient in resisting lateral loads in multi storied buildings. Shear walls are made with steel, reinforced concrete is kept in major positions of multi storied buildings which are made inconsideration of earthquake forces, wind forces. Shear wall must provide necessary lateral strength to resist horizontal earthquake. When shear wall is strong enough, they will transfer these horizontal forces to the next element in the load path below them, such as other shear wall, floors, foundation walls, footings. When building is designed without shear wall, beam and column sizes are quite heavy and there is problem arises at these joint and it is congested to place and vibrate concrete at these places and displacement is quite heavy which induces heavy forces in building member. Shear wall may become essential from the point of view of economy and control of horizontal displacement.

IV. EXPECTED OUTCOME AND NEED TO RESEARCH

The gust and tectonic drags analysis on multi-storey building in seismology zone – 4 i.e. Delhi. The primary objective of this research is to evaluate without fail the highest multi - story structure in the area.,

1. Studying structure with varying heights for evaluation of wind, gusts and earthquake drags.
2. Applying gust forces and tectonic drag to assess various results in high - strength constructions.
3. Correlative analysis of various RCC and composite high-rise structures.

V. OBJECTIVE AND PROBLEM OCCURRED

The foremost goal of this research is to create a model of a mid- to high-rise building and to study its behaviour under wind and seismic loads.

More specifically, the intent of this study is to:

1. The action of gusts loads and the intensity of earthquakes in irregular high structures.
2. To analyse the impact of building form on the actions of the framework in the plan.
3. The identical floor area but variable aspect ratio must be examined.
4. In the structure, lateral displacement can be measured by the effect of gust loads and tectonic forces on various factors such as storage drift.
5. Identifying the most effective aspect ratio of high - rise buildings which can provide the acoustic wind charge and earthquake power by comparative study.
6. In the E-tabs, Stadd-Pro, to model a high rise layout.

As earthquake loads and wind loads are both lateral loads but do not act simultaneously, a decision has to be made about which lateral load is to be used for analysis and design. The procedure of analysis and comparison of Earthquake and Wind forces is illustrated with several examples so that a suitable conclusion can be drawn. Keeping the same floor plan, the analyses are made for 10, 20, 30, 40 and 50 storey and relevant forces and displacements are calculated.

VI. RESULT AND DISCUSSION

I) Seismic Analysis

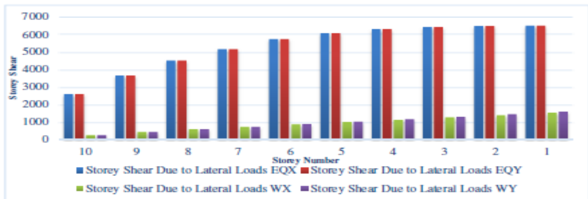

Figure 3 Storey Shear for 10 Storey Building

The figure 3 shows that

- As the storey number decreases the base shear value for EQX, EQY, WX & WY increases.
- Core shear owing to tectonic drags in X-direction and Y-direction (EQX & EQY) is nearly equal at same floor.
- Core shear owing to wind in X-direction and Y-direction (WX & WY) is nearly equal at same floor.
- Core shear owing to tectonic drags is nearly 4 times greater than the core shear owing to gust.

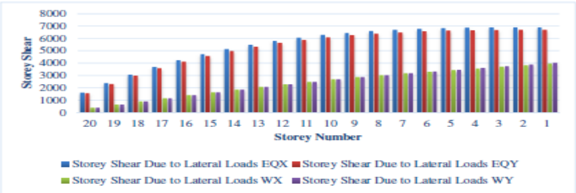

Figure 4 Storey Shear for 20 Storey Building

The figure 4 shows that

- Core shear owing to tectonic drags in X-direction and Y-direction (EQX & EQY) is slightly changed in which EQX is greater than EQY at same floor.
- Core shear owing to wind in X-direction and Y-direction (WX & WY) is slightly changed but nearly equal at same floor.
- Core shear owing to tectonic drags is greater than the core shear owing to wind.
- Core shear owing to tectonic drags up to 5th floor is nearly equal, after 5th floor it goes on decreasing.
- Core shear owing to wind is continuously goes on increasing with deceasing storey number.

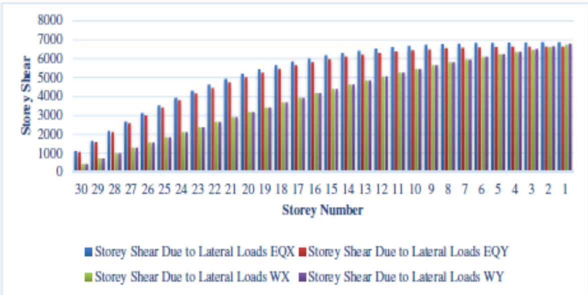

Figure 5 Storey Shear for 30 Storey Building

The figure 5 shows that

- Core shear owing to tectonic drags in X and Y direction (EQX & EQY) is slightly changed in which EQX is greater than EQY at same floor.
- Core shear owing to gust in X and Y direction (WX & WY) is slightly changed but nearly equal at same floor.
- Core shear owing to tectonic drags is nearly equal to the core shear owing to gust.
- Core shear owing to tectonic drags up to 7th floor is nearly equal, after 7th floor it goes on decreasing.
- Core shear owing to gust is continuously goes on increasing with deceasing storey number.

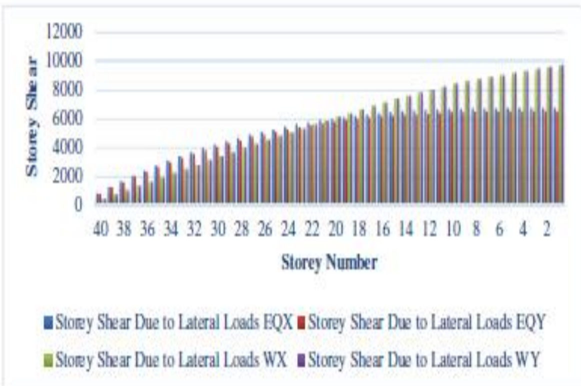

Figure 6 Storey Shear for 40 Storey Building

The figure 6 and shows that

- Core shear owing to tectonic drags in X and Y direction (EQX & EQY) is slightly changed in which EQX is greater than EQY at same floor.
- Core shear owing to wind in X and Y direction (WX & WY) is slightly changed but nearly equal at same floor.
- Core shear owing to tectonic drags is less than the core shear owing due to gust.
- Core shear owing to tectonic drags up to 9th floor is nearly equal, after 9th floor it goes on decreasing.
- Core shear owing to gust is continuously goes on increasing with deceasing storey number.

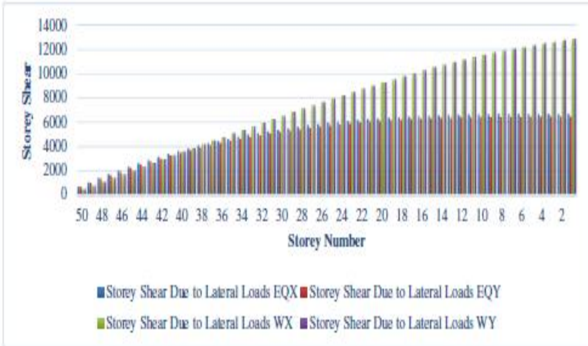

Figure 7 Storey Shear for 50 Storey Building

The figure 7 shows that

- Core shear owing to tectonic drags in X and Y direction (EQX & EQY) is slightly changed in which EQX is greater than EQY at same floor.
- Core shear owing to gust in X and Y-direction (WX & WY) is slightly changed but nearly equal at same floor.
- Core shear owing to gust is nearly double to the core shear due to tectonic drags.
- Base shear due to tectonic drags up to 13th floor is nearly equal, after 13th floor it goes on decreasing.
- Core shear owing to wind is continuously goes on increasing with deceasing storey number.

II) Gust Analysis

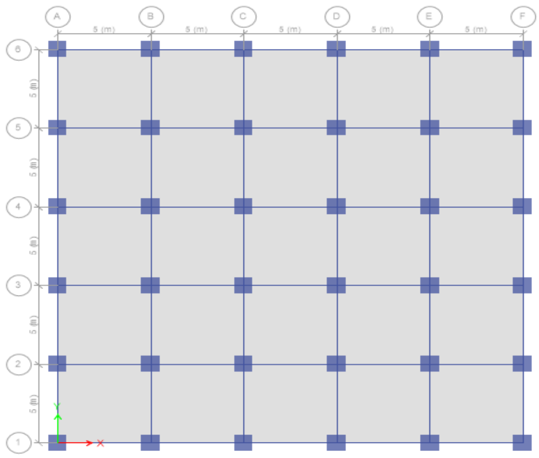

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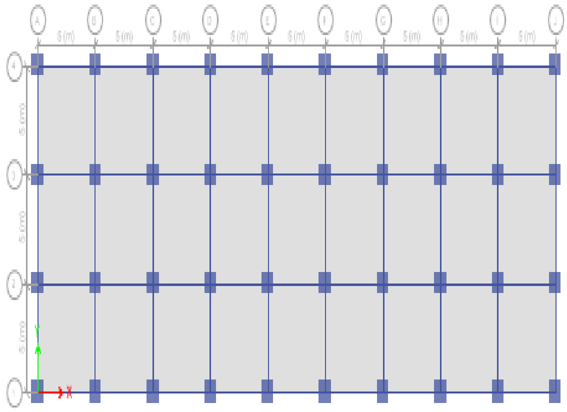
Table 1: Gust Factor of Square Frame

Height	Gust Factor G		
	30 Storey	40 Storey	50 Storey
10	2.27	2.217	2.244
15	2.313	2.261	2.299
20	2.338	2.288	2.33
30	2.372	2.324	2.37
50	2.423	2.388	2.44
90	2.471	2.463	2.52
100		2.463	2.52
120		2.481	2.56
150			2.56

Table 2: Gust Factor for Rectangular Frame

Height(m)	Gust Factor G					
	30 Storeys		40 Storeys		50 Storeys	
	X	Y	X	Y	X	Y
10	2.37	2.22	2.26	2.2	2.17	2.19
15	2.41	2.25	2.3	2.24	2.21	2.23
20	2.43	2.27	2.32	2.27	2.24	2.25
30	2.47	2.29	2.36	2.31	2.28	2.30
50	2.52	2.33	2.41	2.37	2.34	2.32
90	2.56	2.37	2.48	2.44	2.41	2.42
100			2.48	2.44	2.41	2.42
120			2.49	2.46	2.45	2.46
150					2.45	2.46



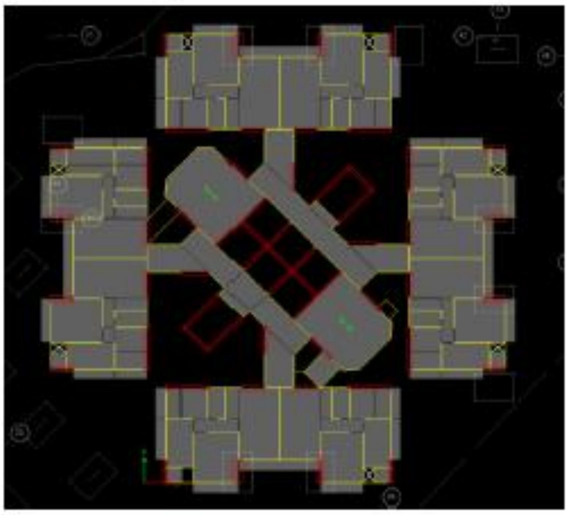


Figure 1 Plan of Building (Snap shot from ETAB)

Table 3: Maximum Storey Response for 30 Storey Frame

	Square Frame		Rectangular Frame			
	Static Method	GEF Method	Static Method		GEF Method	
			X	Y	X	Y
Maximum Storey Displacement (mm)	81.19367	147.086	40.571	190.77	68.786	268.129
Maximum Storey Drift Ratio	0.000223	0.000397	8.4 x 10-5	0.0007	0.00014	0.001
Maximum Storey Shear	4817.802	8413.785	3015.225	10605.77	4911.975	14256

Table 4: Maximum Storey Response for 40 Storey Frame

	Square Frame		Rectangular Frame			
	Static Method	GEF Method	Static Method		GEF Method	
			X	Y	X	Y
Maximum Storey Displacement (mm)	170.3426	280.305	119.419	542.962	165.135	604.973
Maximum Storey Drift Ratio	0.000402	0.000787	0.00019	0.000189	0.000212	0.002101
Maximum Storey Shear	6928.295	13193.55	6286.703	19568.66	6871.455	20906.1

Table 5: Maximum Storey Response for 50 Storey Frame

	Square Frame		Rectangular Frame			
	Static Method	GEF Method	Static Method		GEF Method	
			X	Y	X	Y
Maximum Storey Displacement (mm)	309.7773	671.47	208.119	1032.436	230.357	1153.67
Maximum Storey Drift Ratio	0.0007	0.001516	0.000293	0.003527	0.000323	0.003941
Maximum Storey Shear	9235.666	19275.75	8342.433	25807.62	8903.286	27837

III) DISCUSSION

Tectonic Drags

1. Figure 3 shows the storey shear for 10 storey building goes on decreasing as height of building increases. Maximum storey shear due to tectonic drags is nearly four times that of maximum base shear due to wind.

2. Figure 4 shows that base shear due to both tectonic drags and wind are almost same.

3. Figure 5 & figure 6 shows that base shear due to wind goes on increasing as no of storey increases with respect to earthquake.

4. Figure 7 shows that Core shear by gust is nearly twice the base shear by tectonic drags.

Gust Effectiveness Factor

1. The Gust Factor increases with the increase in height of a particular building.
2. The overall gust factor decreases from one Construction frame to others as the altitude increases.
3. Square frame has smaller surface perpendicular to the wind as compared to rectangular frame. Thus, the wind pressure is observed to be more on rectangular building.
4. Storey Displacement, Storey Drift and Storey Shear obtained using Gust Effectiveness Factor Method is more as compared to that obtained from Static Method.

The Gust Effectiveness Method provides a more realistic and rational approach for wind analysis of a structure. Thus, it should be considered for calculating wind loads on very tall and slender structures.

VII. CONCLUSION

1. It can be observed from the summary that base shear due to tectonic drags remains nearly same irrespective of number of floors, as the number of storeys increases time period also increases resulting in lower acceleration coefficient. Even though building weight increases with number of storeys, there is slight decrease in base shear value due to reduced acceleration coefficient.
2. Building should be designed in both directions independently for critical forces of wind or tectonic drags separately. The total shear force and moment at the base resulted from seismic analysis are more when loads are acting normal to the short side.
3. Tectonic drags are found to be more dominating for short and moderately high building while wind is more for the tall buildings.
4. For Pune city of Maharashtra, buildings with height more than 90m wind load will be critical compared to tectonic drags load.
5. The wind and seismic forces affect more at where irregularity introduced and damage elements at great extent as compare to other portion of structure.
6. As the aspect ratio increase the building become more critical.
7. Effect of wind and tectonic drags force increase for the higher aspect ratio.
8. The tall building should have small aspect ratio i.e. sides of the building should be nearly equal in size, which will make it less critical.
9. The building should square in shape as far as design is a concern.

VIII. ACKNOWLEDGMENT

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