*IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*
*e-ISSN : 2278-1684, p-ISSN : 2320–334X*
*PP 80-89*
*www.iosrjournals.org*

# Effect of Plan Shapes on the Response of Buildings Subjected To Wind Vibrations

B. S. Mashalkar [1], G. R. Patil [2], A.S.Jadhav.[3]

[1] *M.E. (Structure) Student, Department of Civil Engineering Rajarshi Shahu College of Engineering, Tathawade,Pune,Maharashtra-India*
[2] *Assistant Professor Department of Civil Engineering Rajarshi Shahu College of Engineering, Tathawade, Pune, Maharashtra-India Email-* [1] *bhagys.m@gmail.com*
[3] *B.E.Student, Department of Civil Engineering Rajarshi Shahu College of Engineering, Tathawade, Pune, Maharashtra-India*

***Abstract:*** *The development of new architectural forms of buildings and flexible structural systems are vulnerable to wind action. For desirable performance of these buildings, we require better understanding of interaction between building and wind. Structures are classified as rigid and flexible. This paper presents a comparative study of effect of wind on plans with different irregular shapes as I, C, T and L. The significance of this work is to estimate the design load of the structure subjected to wind in a particular region. The wind load is estimated based on basic wind speed and other factors as type of topography, terrain, and the use of building and its risk factor for that particular region. The present investigation deals with the calculation of wind loads for structural frame with different plan shapes and the results are compared with respect to permissible drifts of individual buildings. In this analysis it is found that the amount of drift is considerably changed with respect to shape of the structure. And also found that wind load on the building is maximum when it has maximum exposed area.*

***Keywords****: Wind loads, high rise buildings, drift, irregular plan buildings.*

## I. Introduction

Resent advances in the development of high strength materials coupled with more advanced computational methods and design procedures have lead to a new generation of tall buildings which are slender and light. These buildings are very sensitive to the two common dynamic loads as wind and earthquakes. It is necessary to address the serviceability issue, such as human comfort and integrity of structural components during the strong winds. While designing high-rise buildings and its cladding for wind load, the designers refer to relevant codes/standards to pick the wind pressure coefficients and wind force coefficients. The Indian code IS: 875 (part-3)-1987 gives the design pressure coefficients and force coefficients for buildings having different side ratios and height, but this code remains silent about the pressure coefficients on typical plan shape tall buildings such as L, C, T and I.

The aim of present study is to examine the effects of wind on tall structure under different geometric plan configuration of tall building having same parameters. All the tall buildings with different plan configuration have been modeled in E Tabs software and then comparative study has been executed.

### A. Importance of Wind Loads on the Tall Buildings

Wind is a phenomenon of great complexity because of many flow situations arising from the interaction of wind with structures. Wind is composed of multitude of eddies of varying sizes and rotational characteristics carried along in a general stream of air moving relative to the earth's surface. These eddies give wind its gusty or turbulent character. The gustiness of strong winds in the lower levels of the atmosphere largely arises from interaction with surface features. The average wind speed over a time period of the order of ten minutes or more tends to increase with height, while the gustiness tends to decrease with height.

### B. Effects of wind load

A mean wind force acts on a building. This mean wind force is derived from the mean wind speed and the fluctuating wind force produced by the fluctuating flow field. The effect of the fluctuating wind force on the building or part thereof depends not only on the characteristics of the fluctuating wind force but also on the size

and vibration characteristics of the building or part thereof. Therefore, in order to estimate the design wind load, it is necessary to evaluate the characteristics of fluctuating wind forces and the dynamic characteristics of the building. The factors generally considered in determining the fluctuating wind force are:
1) Wind turbulence (temporal and spatial fluctuation of wind) 2) Vortex generation in wake of building
3) Interaction between building vibration and surrounding air flow for most buildings, the effect of fluctuating wind force generated by wind turbulence is predominant. In this case, horizontal wind load on structural frames in the along-wind direction is important. However, for relatively flexible buildings with a large aspect ratio, horizontal wind loads on structural frames in the across-wind and torsional directions should not be ignored

## II. Literature Review

Isyumov overviews the action of wind on tall buildings and structures with emphasis on the overall wind-induced structural loads and responses also discussed the local wind pressures on components of the exterior envelope and the effects of buildings on winds in pedestrian areas.

Ahsan Kareem his discussion encompasses modeling of wind field; structural aerodynamics; computational methods; dynamics of long -period structures; model – to full-scale monitoring; codes/standards and design tools; damping and motion control devices.

Prof. Sarita Singla, Taranjeet Kaur, Megha Kalra and Sanket Sharma Behaviour of R.C.C. Tall Buildings Having Different Shapes Subjected to Wind Load.

Ritu Raj and Ashok Kumar Ahuja Wind Loads on Cross Shape Tall Buildings It is observed that base shear, base moments and twisting moments developed due to wind loads are not only influenced by wind directions, but also highly affected by cross-sectional shapes.

M. Glória Gomes, A. Moret Rodrigues, Pedro Mendesn were discussed about Wind Effects On And Around L- And U-Shaped Buildings with experimental models.

### I.I Objective of the study

i. To Study the behavior of tall structures when subjected to along wind loads.

ii. To study the effect of shape of the building in plan on the behavior of the structure.

iii. To determine the effect of wind load on various parameters like storey drifts, lateral displacements in the building.

## III. Scope Of The Present Study

The scope of the present work included the study of the wind load estimation on tall buildings for the structural design purpose with the analytical approach in IS 875: part 3-1987 and the analysis of the building had been done by using E tabs software and the performance was analyzed by varying the shape of structure.
Different shapes of the building studied were:

a) L shape

b) C shape

c) I shape

d) T shape

## IV. Parameters Of The Building

1. Different cases of the building analysed were as under:

a) G+11 storeyed L shaped framed building. (Fig. 1)

b) G+11 storeyed C shaped framed building. (Fig. 2)

c) G+11 storeyed I shaped framed building. (Fig. 3)

d) G+11 storeyed T shaped framed building. (Fig. 4)

Various parameters of the buildings adopted were as under: Total Height = 34.5 m

Grid Size = 4 m x 4 m

Size of Columns = 450 mm x 450 mm

Size of Beams at each floor = 200mm x 600 mm

Thickness of slab = 150mm

Grade of Concrete in Columns = M30

Grade of Concrete in Beams = M20

Grade of steel = Fe 500

All supports were assumed to be fixed.

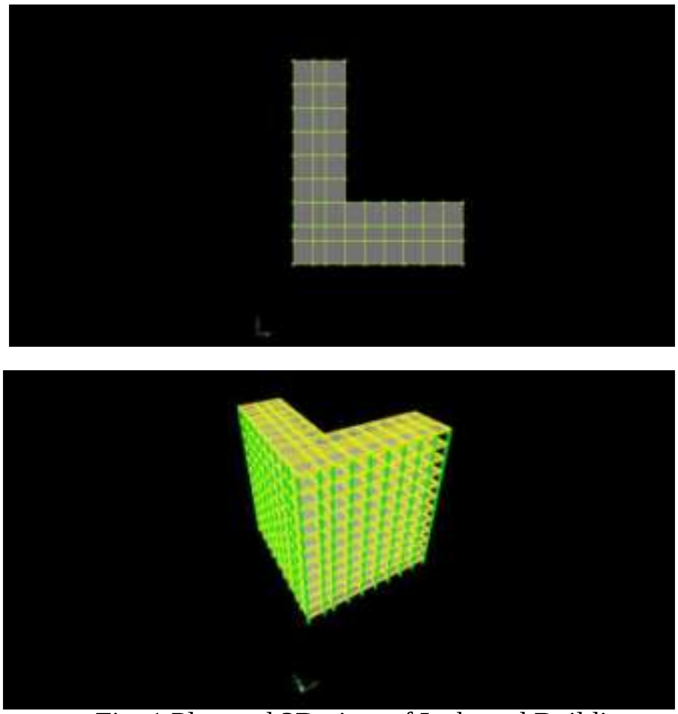
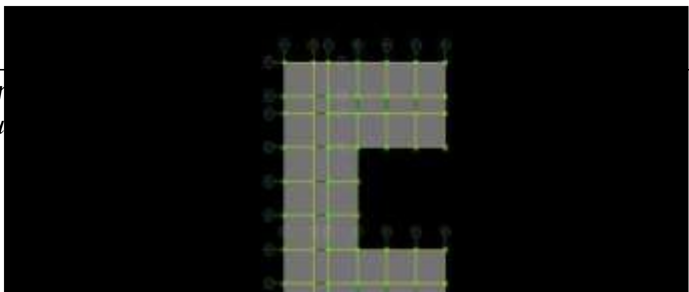


Fig. 1 Plan and 3D view of L shaped Building



*IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*
*e-ISSN : 2278-1684, p-ISSN : 2320–334X*
*PP 80-89*
*www.iosrjournals.org*

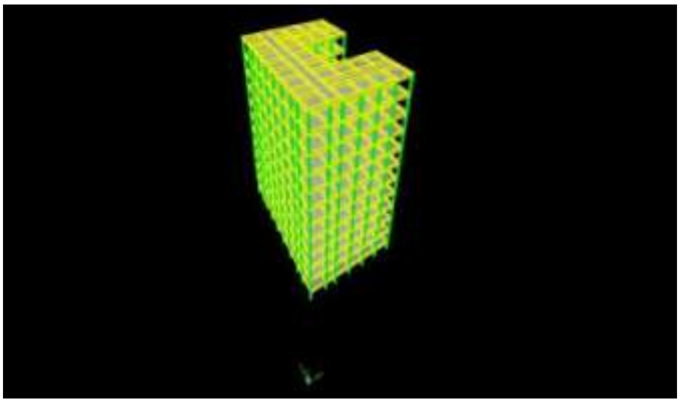
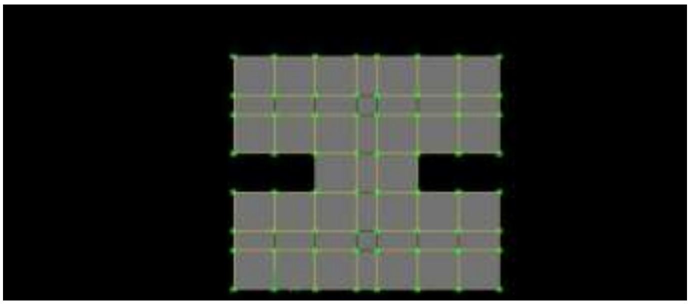
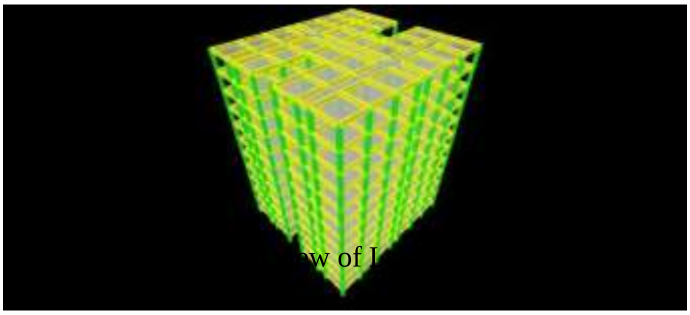


Fig. 2 Plan and 3D view of C shaped Building





ew of I

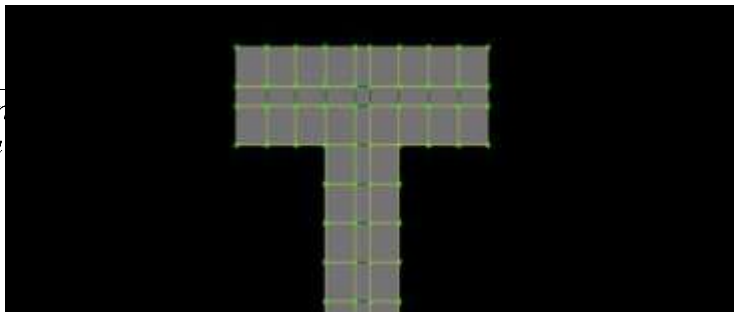


Fig. 4 Plan and 3D view of T shaped Building

**A. Loadings Considered**

i. Dead Loads:The loads of the beams and columns had been taken in account by E tabs.
ii. LiveLoad-The live loads had been taken as 3.00 kN/$m^2$ at all floors.
iii.Super dead load had been calculated and applied to slabs and beams i.e SDL = 9KN/$m^2$.

**B. Wind Load Calculations based Upon the Codal Provisions**

For all buildings with different shapes parameters considered are same throughout the structural frame. The models were analysed in E tabs for Pune region.
Parameters considered for Wind analysis are as follows: Terrain Category: III
Structure Class: B
Basic Wind Velocity, Vb : 39 m/s

**L Shape**:
Plan Length: 34.5m
Plan Width: 34.5m Face width = 34.5 m; Face depth = 34.5 m k1 = 1;

k3 = 1;

Vb = 39 m/s

Vz = Vb x k1 x k2 x k3

Cf = 1.25

**C Shape**:

Plan Length: 33m Plan Width: 22.5m Face width = 33 m; Face depth = 34.5 mk1=1
k3 = 1;

Vb = 39 m/s

Vz = Vb x k1 x k2 x k3

Cf = 1.25

**I Shape**:
Plan Length: 24m Plan Width: 26m Face width = 24 m; Face depth = 34.5 m k1 = 1;

k3 = 1;

Vb = 39 m/s

Vz = Vb x k1 x k2 x k3

Cf = 1.23

## T Shape:

Plan Length: 34m Plan Width: 10m Face width = 24 m; Face depth = 34.5 m $k_1$ = 1;
$k_3$ = 1;

$V_b$ = 39 m/s

$V_z = V_b \times k_1 \times k_2 \times k_3$ $C_f$ = 1.23

## C. Load Combinations

Load combinations were considered as per IS 875(part 5)

**Table I. Wind Forces At Different Height Of The Building in KN** $V_b$= 39m/s

| HEIGHT | L SHAPE | I SHAPE | C SHAPE | T SHAPE |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| STOREY 1 | 42.06 | 31.29 | 44.9 | 44.33 |
| STOREY2 | 84.12 | 62.59 | 89.98 | 88.66 |
| STOREY3 | 84.12 | 62.59 | 89.98 | 88.66 |
| STOREY4 | 84.46 | 62.84 | 90.34 | 89.03 |
| STOREY5 | 88.83 | 66.1 | 95.02 | 93.64 |
| STOREY6 | 95.59 | 71.12 | 102.34 | 100.75 |
| STOREY7 | 100.94 | 75.1 | 107.97 | 106.4 |
| STOREY8 | 105.3 | 78.35 | 112.63 | 110.99 |
| STOREY9 | 108.63 | 80.82 | 113.19 | 114.5 |
| STOREY10 | 111.91 | 83.27 | 119.7 | 117.96 |
| STOREY11 | 115.02 | 85.58 | 123.03 | 121.23 |
| TERRACE | 58.29 | 43.37 | 62.35 | 61.44 |

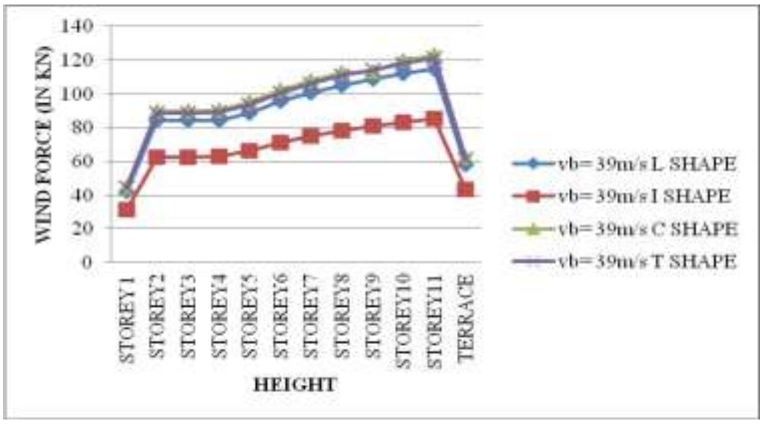



Fig.5 Variation of Wind Force with height

## V. Results And Discussion

The behavior of different buildings when subjected to wind load have been discussed further.

### A. Effect of the Shape of the Building on Storey Drifts:

The Storey drifts for L, C, Tand I shaped building are compared in Table II and Fig.6.

**Table II. Storey Drifts At Different Heights in M.**

| STOREY | $V_b$=39m/s | | | | | | |
|---|---|---|---|---|---|---|---|
| | T | L | % Decrease | C | % Decrease | I | % Decrease |
| STOREY 1 | 0.312 | 0.218 | 30.12 | 0.146 | 53.20 | 0.105 | 66.34 |
| STOREY2 | 0.703 | 0.611 | 13.08 | 0.409 | 41.82 | 0.294 | 58.17 |
| STOREY3 | 0.785 | 0.696 | 11.33 | 0.454 | 42.16 | 0.316 | 59.74 |
| STOREY4 | 0.762 | 0.674 | 11.54 | 0.433 | 43.17 | 0.298 | 60.89 |
| STOREY5 | 0.716 | 0.632 | 11.73 | 0.4 | 44.13 | 0.275 | 61.59 |
| STOREY6 | 0.66 | 0.58 | 12.12 | 0.363 | 45 | 0.248 | 62.42 |
| STOREY7 | 0.595 | 0.521 | 12.43 | 0.322 | 45.88 | 0.219 | 63.19 |
| STOREY8 | 0.523 | 0.455 | 13.00 | 0.276 | 47.22 | 0.188 | 64.05 |
| STOREY9 | 0.444 | 0.385 | 13.28 | 0.228 | 48.64 | 0.154 | 65.31 |
| STOREY10 | 0.361 | 0.311 | 13.85 | 0.178 | 50.69 | 0.119 | 67.03 |
| STOREY11 | 0.276 | 0.236 | 14.49 | 0.128 | 53.62 | 0.083 | 69.92 |
| TERRACE | 0.2 | 0.169 | 15.5 | 0.083 | 58.5 | 0.051 | 74.5 |

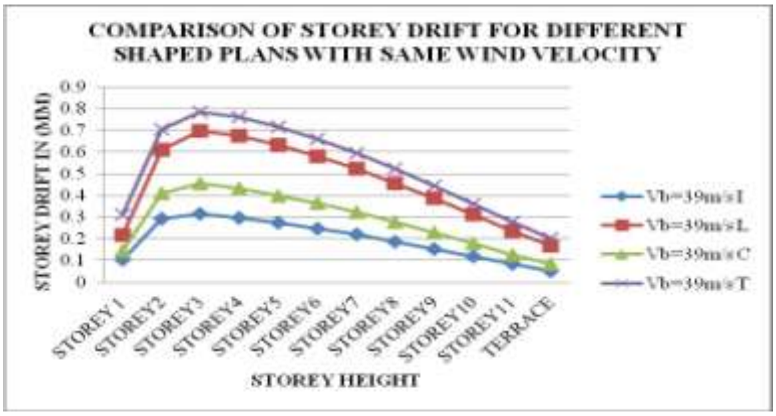



Fig. 6. Variation of Storey drift

Peak Storey drift is minimum as compared to intermediate storey's i.e for T shaped building it is 0.2 mm, in L shaped building it is 0.169 mm, in C shaped building it is0.083mm and in I shaped building is 0.051 mm. The percentage reduction in peak storey drift in L shaped building is 15.5%, C shaped building is 58.5% and in I building is 74.5% as compared to peak storey drift in T building. From Figure 6 it is clear that the storey drifts are reduced with the increase in number of sides of the building with the same column stiffness and grid size due to reduction in effective area (Ae) of wind load application.

**B. Effect of the Shape of The Building on Lateral Displacements:**
**Table III. Comparison Of Lateral Displacements in M.**

| STOREY | Vb=39m/s | | | | | | |
|---|---|---|---|---|---|---|---|
| | T | L | % Decrease | C | % Decrease | I | % Decrease |
| STOREY 1 | 0.5 | 0.3 | 40 | 0.2 | 60 | 0.2 | 60 |
| STOREY2 | 2.6 | 2.2 | 15 | 1.4 | 46.1 | 1 | 61.5 |
| STOREY3 | 4.9 | 4.2 | 14 | 2.8 | 42.8 | 2 | 59.1 |
| STOREY4 | 7.2 | 6.2 | 14 | 4.1 | 43.05 | 2.9 | 59.72 |
| STOREY5 | 9.4 | 8.1 | 13.8 | 5.3 | 43.61 | 3.7 | 60.6 |
| STOREY6 | 11.4 | 9.8 | 14.03 | 6.4 | 43.8 | 4.5 | 60.5 |
| STOREY7 | 13.1 | 11.4 | 13 | 7.4 | 43.5 | 5.1 | 61.0 |
| STOREY8 | 14.7 | 12.7 | 13.6 | 8.2 | 44.2 | 5.7 | 61.2 |
| STOREY9 | 16 | 13.8 | 13.75 | 8.9 | 44.37 | 6.1 | 61.8 |
| STOREY10 | 17.1 | 14.7 | 14.0 | 9.4 | 45.0 | 6.5 | 61.9 |
| STOREY11 | 17.9 | 15.4 | 14 | 9.8 | 45.25 | 6.7 | 62.5 |
| TERRACE | 18.5 | 15.8 | 14.5 | 10 | 45 | 6.9 | 62.7 |

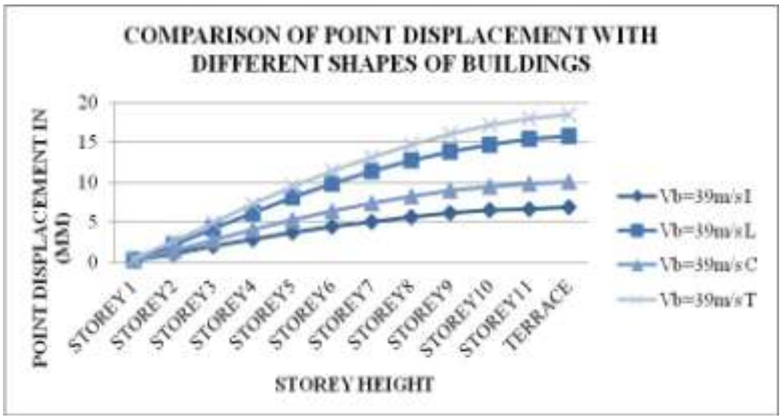



Fig. 7. Variation of Lateral Displacements with height

The lateral joint displacements in L, C, T and I shaped buildings at different heights are compared in Table 3 and Figure 7. From the results, it is observed that with the change in shape of building from T to I, the lateral displacements of the building decreases.

It is minimum at the bottom most part and increasing with height of the building and maximum at the top of the building. Shape affects on the point displacement of the structure. Point displacement of T shaped building is more as compared to L, C and I shaped buildings. The peak point displacement in case of T building is 18.5 mm, for L building it is 15.8 mm, for C building it is 10 mm and for I, it is 6.9 mm.

## VI. Conclusions

A G+11 storied building of different shapes- T, L, C and I, having Same parameters with equal stiffness of the columns at each storey has been analyzed.

- With the change in shape of building from T to I, the storey drifts and the lateral displacements of the building decreased.
- The percentage reduction in peak storey drift in L shaped building is 15%, in C building is 58.6% and in I building is 74.5% as compared to peak storey drift in T building.
- Based upon the above results, it is concluded that shape of the structure plays an important role in resisting wind loads. I shaped building has lesser storey drifts, lesser lateral displacements at the points as compared to T, L and C shaped building.
- From the above discussion, it can be concluded that as velocity increases, the storey drift and storey displacement also increases.
- It has been observed that displacement and storey drift in T, C and L shaped buildings is more than I shaped building. This may due to asymmetry of T, C and L type buildings.
- This is due to the distance of extreme point of building from CG is more in case of T, C and L type plan than I type plan.

## Acknowledgment

In the process of preparing and completing this paper, I was in contact either directly or indirectly with many people, academicians and wholesaler. They have contributed towards my understanding and thought.

In particular, I wish to express my greatest appreciation to my Guide, Prof. G. R. Patil, for his encouragement, guidance, critics, and motivations. Without his continued support and interest, this study would have been the same as presented here. I am deeply indebted to our Prof. R. S. Karale, Head of The Department (Civil Engineering) and to our principal sir Dr. D. S. Bormane.

At the same moment, I am grateful to all my family members for their support and encouragement. My sincere appreciations also to my friends for their support and help.

I hope my findings in this study will expand the knowledge in this field and contribute to all of us in future.

## References

[1]. Is 875: (1987). Indian Standards Code Of Practice For Design Loads For Buildings And Structures Part.3 - Wind Loads. Bureau Of Indian Standards, India.
[2]. J. A. Amin* And A. K. Ahuja Experimental Study Of Wind Pressures On Irregularplan Shape Buildings
[3]. Jigar K. Sevaliaa, Dr. Atul K. Desaib And Dr. S. A. Vasanwala, Effect Of Geometric Plan Configuration Of Tall Building On Wind Force Coefficient Using Cfd.
[4]. Baskaran T. And Stathopoulos T., “Computational
[5]. Evaluation Of Wind Effects On Buildings”, Building And Environment, Vol. 24 91989), No. 4, Pg. 325-333.
[6]. Gloria Gomes M., Moret Rodrigues A. And Pedro Mendes, “Experimental And Numerical Study Of Wind Pressures On Irregular-Plan Shapes”, Journal Of Wind Engineering And Industrial Aerodynamics, Vol. 93 (2005), Pg. 741–756.
[7]. Zhou, Yin. 1999 “Alongwind Static Equivalent Wind Loads And Responses Of Tall
[8]. Buildings. Part I: Unfavorable Distributions Of Static Equivalent Wind Loads.” Jurnal Of
[9]. Wind Engineering And Industrial Aerodynamics. Elsevier Science Ltd. Vol.79, Pages 135-150
[10]. Mendis, P.. 2007 “Wind Loading On Tall Buildings.” Ejse Special Issue: Loading On Structures.
[11]. Higgins, Theodore R. 1979 “Structural Design Of Tall Steel Buildings: Council On Tall Buildings And Urban Habitat” Vol. Sb. American Society Of Civil Engineers.
[12]. Dr. K. R. C. Reddy, Sandip A. Tupat, The Effect Of Zone Factors On Wind And Earthquake Loads Of High-Rise Structures Iosr Journal Of Mechanical And Civil Engineering (Iosr-Jmce) E-Issn: 2278-1684, P-Issn: 2320-334x Pp 53-58
[13]. Raj, R., Kumar, A., and Ahuja, k.(2013). „ Wind load on I-shape tall buildings‟, Int. Jour of Scientific
[14]. Research & Development , Vol.01, May-Jun 2013, pp 20-23.
[15]. Raj, R., Kumar, A., and Ahuja, k.(2013). „Wind Loads on Cross Shape Tall Buildings‟ , J. of Academia and Industrial Research ,Volume 2, July 2013, pp 111-113.
[16]. Haldera, L., and Duttab, S. C.(2010).‟ Wind effects on multi-stored building: A critical review of Indian
[17]. codal provisions with special referance to American standard‟, Asian Journal of Civil Engg, Vol. 11, No. 3 (2010), pp 345-370.