

Comparative analysis of wind load on different non-circular shaped buildings

Kiran Kumar ¹

¹Assistant Professor, Department of Civil Engineering,
Saveetha Institute of Medical and Technical Sciences
Thandalam, Chennai, Tamilnadu.
E-mail: kirankumar.jagdish@gmail.com

U. Dhiyaanesh ²

²Bachelor of Engineering, Department of Civil Engineering,
Saveetha Institute of Medical and Technical Sciences
Thandalam, Chennai, Tamilnadu.
E-mail: dhaanu.kumar97@gmail.com

Abstract: Buildings were constructed to provide shelter for people and for commercial uses. Due to rapid increment in population and higher rate of growth in industries there is a large demand for land. To occupy less land and to provide the area required for usage vertically tall buildings were started to be constructed. Tall buildings behave differently when compared to short buildings. This is since seismic loads and wind loads have adverse effect on tall buildings. But the effect of wind loads varies depending on shape of the buildings. It is well known form study that buildings having non-angular shapes perform well against wind loads. But, it is not always possible design buildings in non-angular shapes due to change in requirements. While designing a building some commonly used shapes are C Shape, PLUS Shape and RECTANGLE Shape which are used for the analysis. Three plans of C Shape, PLUS Shape and RECTANGLE Shape having equal areas are made and their resistance against the wind effect is found out. Among the three shapes PLUS Shape performed well against the wind which was followed by C Shape and the least resistance was given by RECTANGLE Shape.

Key words: Tall buildings, c shape, plus shape and rectangle shape

1. Introduction

Wind load and seismic load are the most important loads to be considered while designing tall buildings. These loads are given due importance because of their highly varying effect on buildings. The effect of these loads may vary from zero to extreme levels. The idea of the project is compare the effect of wind loads on some of the commonly used non-circular shapes. The shapes taken for the comparison are C Shape, PLUS Shape and RECTANGLE Shape. The buildings should be designed in a way that it should have sufficient resistance against the wind by the way it should be economical too. To achieve such results, the size of structural members is kept to minimal without affecting the stability of the structure. The three plans are made in a way that they all have same areas. The structures raised and their reactions on ground and deflections are compared to find the efficiency of structures. each building is raised to three heights 4 floors, 10 floors and 15 floors to

provide a reference for future buildings in terms of column and beam sizes.

2. Methodology

Plan of the three buildings (C Shape, PLUS Shape and RECTANGLE Shape) are made using AutoCAD 2018 for an area of 600 m² each.



Fig 1: C Shape plan



Fig 2: PLUS Shape plan

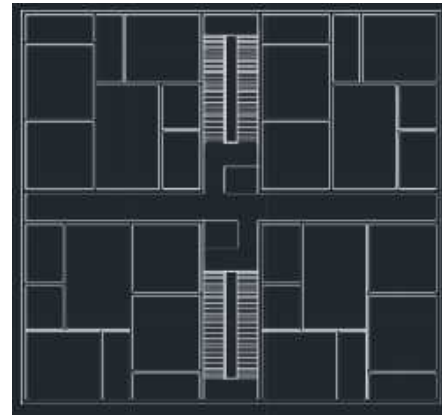


Fig 3: RECTANGLE Shape plan

All the buildings three houses, two elevators and 2 stairs each building is raised for three heights 4 floors, 10 floors and 15 in STAAD.Pro connection edition. The member properties are assigned, and the loads are assigned with reference to the following code books.

- IS 456:2000 (Concrete)
- SP 16 and SP 32 (steel)
- IS 875 PART 1 (Dead load)
- IS 875 PART 2 (Live load)
- IS 875 PART 3 (Wind Load)

Concrete design is done in STAAD.Pro and the member properties are changed to make the structure safe. After the structure is made safe, deflection, reaction on the ground, percentage of reinforcement and size of columns are noted down. Then comparison is made with the noted values. The comparison gives the results.

3. Literature study

Prof. Sarita Singla et al., (2012) this paper deals with buildings which are designed for utilization by the people as shelter for living. As nowadays there is shortage of land for building, the vertical construction is given due importance. A building

designer is interested in horizontal forces acting on each storey for analysis and design of structure. So, the priority is given for the identification of lateral forces due to wind on building. Buildings of different shapes- Square, Hexagonal and Octagonal, having similar plan area has been analysed. The study reveals that the effect of wind load highly depends on the shape of the building. Octagonal shaped building gives the best result followed by hexagonal shaped building and square shaped building.

B. S. Mashalkar et al., (2017) this deals with the development of buildings which are vulnerable to wind action. To design the high-rise buildings in a much effective way, better understanding of interaction between building and wind is required. This paper gives comparative study of effect of wind on plans with a variety irregular shape as I, C, T and L. The wind load is estimated based on basic wind speed for that region the outcome of the study gives the calculation of wind loads for structural frame with different plan shapes and the permissible drifts of individual buildings and found that wind load on the building is maximum when it has maximum exposed area.

Megha Kalra et al., (2011) this paper says that the direction of wind is horizontal relative to the surface of earth. The primary generating force behind wind is the constant rotational movement of earth and terrestrial radiations of varying intensity. The radiation results in the convection currents in two directions - upwards or downwards. The nature of wind is very unpredictable, even for the same locality the wind speeds are extremely different, one may experience the effect of gusts lasting for few seconds. The effect of wind on a structure thus depends on

many factors like its geographical location and obstructions near the structure which may cause any variation in air flow and the characteristics of the structure itself. Plus shape and Non-uniform shape were the most stable shapes whereas L-shape and U-shape was the least stable of all the shapes. More the stiffness of the building more will be its stability. Storey drift and joint displacement increases with increase in height

Anupam Rajmani et al., (2015) this paper says that wind is one of the most powerful force affecting tall buildings. Tall buildings are attached to the ground, they bend and sway in the wind. This is known as wind drift, should be kept under acceptable limits. For a properly designed building, the wind drift should not be higher than the height of the building divided by 500. Wind loads on buildings increase considerably with the increase in building heights. In respect to nodal shape triangle shape performs better than other shapes.

Prof. M. R. Wakchaure et al., (2016) In this paper, buildings having same area, but different shapes are compared. Wind loads are determined based on gust effectiveness factor method. The critical gust loads for design are determined. Elliptical or circular buildings have a smaller surface area perpendicular to the wind direction. The wind pressure is less than in prismatic and square shaped buildings. Prismatic and square shaped buildings are less stable against wind load than elliptical buildings. Hence it is concluded that wind load is reduced with an elliptical plan.

Rohan Kulkarni et al., (2016) Most prominent buildings are called high-rise buildings in many countries from the structural design point of view, it

is simpler to consider a building as a tall building when the structure is affected by the lateral loads i.e., wind or seismic and particularly the sway caused by such lateral loads. As the height increases, the wind forces begin to have a devastating effect. Therefore, framework for tall buildings is developed entirely with resistance of the building towards turbulent wind in mind. Circular and elliptical plan shape of buildings is much better compared to the other plan shape of building in reducing of both Wind Pressure Coefficient as well as Total Drag Force on Building.

4. Parameters

- 1) Different case of buildings
 - A). 4 Storeyed Building of C- Shape
 - B). 4 Storeyed Building of Plus- Shape
 - C). 4 Storeyed Building of Rectangle- Shape
 - D). 10 Storeyed Building of C- Shape
 - E). 10 Storeyed Building of Plus- Shape
 - F). 10 Storeyed Building of Rectangle- Shape
 - G). 15 Storeyed Building of C- Shape
 - H). 15 Storeyed Building of Plus- Shape
 - I). 15 Storeyed Building of Rectangle- Shape
- 2) Plan area= 600m²
- 3) Grade of concrete used = M30
- 4) Min size of primary reinforcement = 12mm
- 5) Max size of primary reinforcement = 32mm
- 6) Min size of secondary reinforcement = 8mm
- 7) Max size of secondary reinforcement = 12mm
- 8) Grade of steel = Fe415
- 9) Supports = Fixed
- 10) Loads
 - a) Self-weight -1kn/m
 - b) Wall loads
 - i) -16.2kn/m
 - ii) -10.8 kN/m
 - c) Slab load -4kn/m
 - d) Live load -3kn/m
 - e) Wind speed 40 m/sec

11) Load combinations

- a) 1.5*Dead Load+1.5*Live Load
- b) 1.2*Dead Load+1.2*Live Load+1.2*Wind Load
- c) 1.5*Dead Load+1.5*Wind Load
- d) 1*Dead Load+1*Live Load
- e) 1*Dead Load+1*Live Load+1*Wind Load

5. Results

Shape of Building	Maximum Displacement
C shape	-0.002
Plus Shape	0.001
Rectangle shape	0.005

Table 1: Results for resistance against wind load

Building shape and height	Size of Columns
C Shape 4 Floors	0.3*0.4
C Shape 10 Floors	0.3*0.4
C Shape 15 Floors	0.3*1.2
Plus Shape 4 Floors	0.3*0.4
Plus Shape 10 Floors	0.3*0.6
Plus Shape 15 Floors	0.3*1.3
Rectangle Shape 4 Floors	0.3*0.4
Rectangle Shape 10 Floors	0.3*0.7
Rectangle Shape 15 Floors	0.3*1.3

Table 2: Size of Columns

Floor	Percentage of Steel for Each Floor		
	C Shape	Plus Shape	Rectangle Shape
1	1.39%	1.50%	1.28%
2	1.39%	1.28%	1.28%
3	0.89%	1.28%	1.28%
4	0.89%	1.28%	1.28%
5	0.89%	1.28%	1.28%
6	0.62%	1.28%	1.28%
7	0.62%	1.28%	1.28%
8	0.62%	1.28%	1.28%
9	0.50%	1.28%	1.28%
10	0.50%	1.28%	1.28%
11	0.50%	1.28%	1.28%
12	0.50%	1.28%	1.28%
13	0.50%	1.28%	1.28%
14	0.50%	1.28%	1.28%
15	0.50%	1.28%	1.28%

Table 3: Percentage of Reinforcement

6. Conclusion

The comparative analysis between three angular shapes C Shape, Plus Shape and Rectangular Shape was made to find out which of these three shapes is more efficient against wind load, which one is a more economical structure and to provide a basic information about the column sizes to be used for the buildings of three different heights, 4 floors 10 floors and 15 floor buildings. That comparative analysis gives a result that Plus shape is the most efficient section against wind followed by C shape and Rectangle. C shape is the most economical section which is followed by Rectangle and Plus shape. Finally, it can be concluded by saying that if one needs stability Plus shape can be chosen, if economy is the priority C shape can be chosen. Rectangle shape stays back in both efficiency and economy.

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