

# Comparative of High Rise Building with Same Height and Floor Area Having Different Shape Against Wind Load Analysis using Is 875 (Part-3)

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**Abstract-** The present study investigates the influence of building plan configuration on the wind-induced structural behaviour of high-rise reinforced concrete buildings. Three G+12 building models having square, rectangular, and circular plan configurations are comparatively analysed while maintaining the same building height and floor area. The study aims to evaluate the effect of plan geometry on important structural response parameters under wind loading. Wind loads are determined in accordance with IS 875 (Part 3):2015, considering the relevant wind speed, terrain, topography, and structural parameters. The structural models are analysed using STAAD/ETABS under identical structural, loading, and support conditions. The comparative assessment considers parameters including lateral displacement, storey drift, base shear, torsional behaviour, and fundamental time period. The analysis is based on linear static wind-load evaluation of reinforced concrete moment-resisting frame structures. The results demonstrate that variation in plan geometry significantly influences the lateral response and overall structural behaviour of high-rise buildings. The rectangular configuration exhibits comparatively higher lateral displacement, while the circular configuration shows comparatively lower displacement in the analysed models. The study highlights the importance of considering plan geometry during the preliminary planning and structural design of high-rise buildings. The findings provide useful guidance for selecting an efficient plan configuration for improved wind resistance, structural safety, and serviceability.

**Keywords -** Building plan configuration; high-rise reinforced concrete buildings; wind-induced structural behaviour; wind loading; lateral displacement; storey drift; base shear; torsional behaviour; fundamental time period; IS 875 (Part 3):2015; moment-resisting frame.

## I. INTRODUCTION

Rapid urbanization and increasing population density in modern cities have led to the construction of high-rise buildings as an effective solution for optimal land utilization. With the increase in building height, structures become more flexible and slender, making them highly sensitive to lateral loads, particularly wind loads. Unlike low-rise buildings,

where gravity loads dominate design considerations, the design of high-rise buildings is primarily governed by lateral forces such as wind and seismic effects.

Wind load is one of the most critical environmental loads acting on high-rise structures. It significantly influences structural safety, serviceability, and occupant comfort. Wind effects induce lateral displacement, storey drift, torsional response, and additional stresses in structural members, which must be carefully evaluated during structural design.

The magnitude of wind load acting on a building depends on several parameters including building height, terrain conditions, topography, wind velocity, exposure conditions, and most importantly, plan configuration of the structure. The geometry of a building plays a crucial role in determining its aerodynamic behaviour under wind action. Buildings with symmetrical plan shapes generally perform better than irregular plan configurations because they reduce torsional effects and distribute lateral forces more uniformly.

Irregular plan shapes such as L-shape and T-shape buildings experience larger torsional moments due to eccentricity between the centre of mass and centre of rigidity. On the other hand, regular configurations such as square, rectangular, and circular shapes provide better resistance against wind forces due to uniform stiffness distribution.

In India, wind load estimation for structural design is carried out according to IS 875 Part 3, which provides procedures for determining design wind speed, wind pressure distribution along the height of buildings, terrain effects, topographical factors, and load combinations for safe structural design.

Therefore, it becomes essential to evaluate the influence of building plan geometry on structural response under wind loading conditions. A comparative study of high-rise buildings with different plan shapes helps in identifying the most efficient structural configuration that minimizes lateral displacement, storey drift, torsional effects, and internal forces.

The present study focuses on analysing and comparing the behaviour of high-rise reinforced concrete buildings having different plan configurations subjected to wind loads calculated as per IS 875 (Part 3) using advanced structural analysis software such as ETABS. The results obtained from the analysis will help in understanding the influence of plan shape on wind performance and assist in selecting suitable geometries for efficient structural design of high-rise buildings.

## II. METHODOLOGY AND MATERIAL CHARACTERIZATION

### A. METHODOLOGY OR STEPS

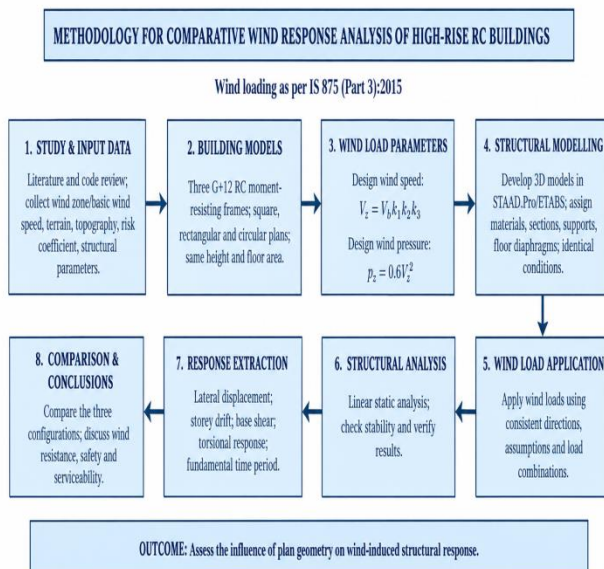


Fig 1: Flowchart of the Structural Analysis and Comparative Evaluation Process.

TABLE 1: GEOMETRICAL CONFIGURATION OF THE BUILDINGS

| Shape       | Dimension    | No. of bays |
|-------------|--------------|-------------|
| Square      | 25m x 25m    | 7           |
| Rectangular | 36.76m x 17m | 12          |
| Circular    | Dia -28.2m   | 9           |

### B. MODEL DETAILS

The structural members in this project are designed using standard materials as per Indian Standards. M30 grade concrete is used for RCC members, Fe 550 grade steel is used as reinforcement. These materials provide adequate strength, durability, and wind performance for the building.

### C. STRUCTURAL SYSTEM FOR THE BUILDINGS

The structural system for the buildings has been evolved on the basis of various aspects like functional requirements of the building, durability and life span of building, cost effectiveness and other design criteria requirements specified by discussions on number of meetings with client.

### D. RELEVANT CODES FOLLOWED FOR DESIGN

The main design standards followed for structural design are given below, indicating their area of application.

For Loading:

IS 875(Part 1):1987-Dead loads.

IS 875(Part 2):1987-Imposed load.

IS 875(Part 3):2015-Wind Loads.

For Design of Reinforced Concrete:

IS 456:2000-Code of practice for plain and reinforced concrete (Fourth Revision)

### E. DESIGN PARAMETERS AND VALUES

TABLE 2: WIND ANALYSIS AND DESIGN INPUT PARAMETERS

| Sl.No. | Input Parameter                                     | Value                    |
|--------|-----------------------------------------------------|--------------------------|
| 1.     | Basic Wind Speed, $V_b$                             | 39                       |
| 2.     | Risk Co-Efficient, $K_1$                            | 1.07                     |
| 3.     | Topography Co-Efficient, $K_3$                      | 1                        |
| 4.     | Terrain Category                                    | 2                        |
| 5.     | Class Of Structure                                  | B                        |
| 6.     | The Value Of Height And Structure Size Factor $K_2$ | Value Varies with Height |

### F. AutoCAD Layout Plan and 3d- Rendered Views of Different shaped Building

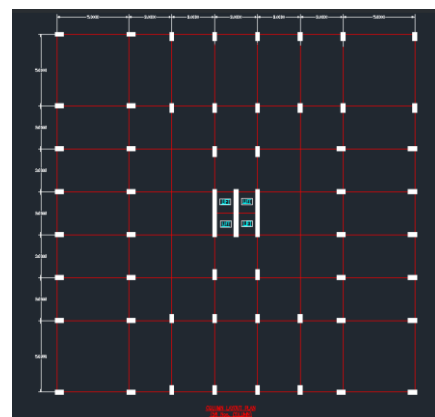


Fig. 2: (a) Square Building - AutoCAD Layout dimension 25m x 25m - Height 41.7m

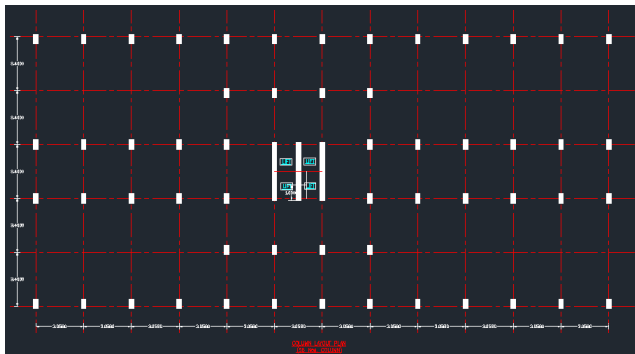


Fig. 2: (b) Rectangular Building - AutoCAD Layout dimension  
 26.76m x 17m - Height 41.7m

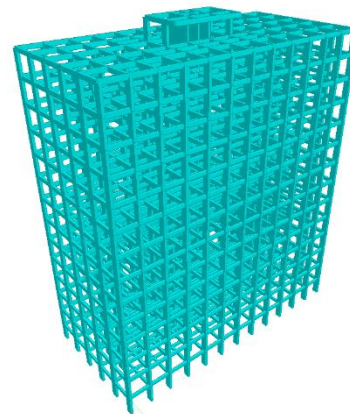


Fig 3: (b) 3-D Rendered view of Rectangular Building.

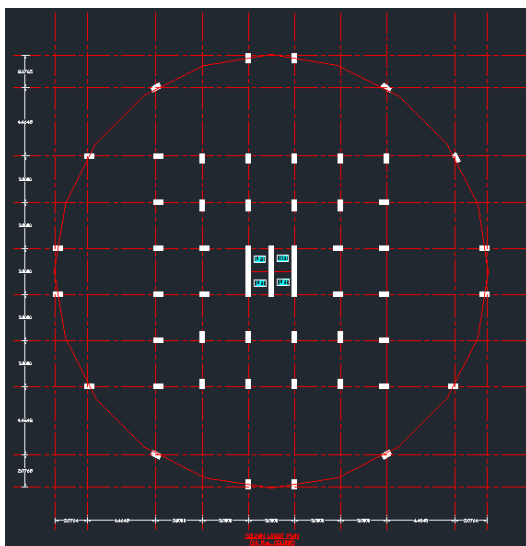


Fig. 2: (c) Circular Building -AutoCAD Layout dimension  
 Dia-28.2m - Height 41.7m



Fig 3: (c) 3-D Rendered view of Circular Building.

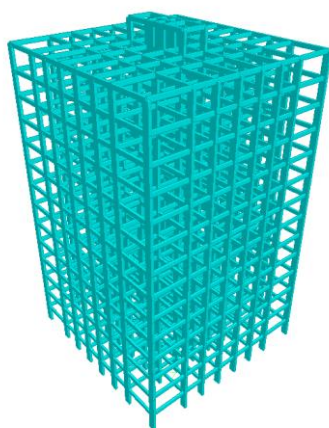


Fig 3: (a) 3-D Rendered view of Square Building.

### G. Wind Load Acting towards Different shaped Building.

#### WIND LOAD ACTING IN SQUARE BUILDING IN EVERY DIRECTION

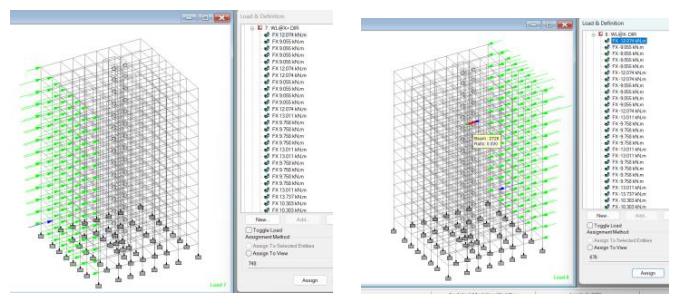


Fig-4 (a) Wind load in X(+) & X(-) Direction

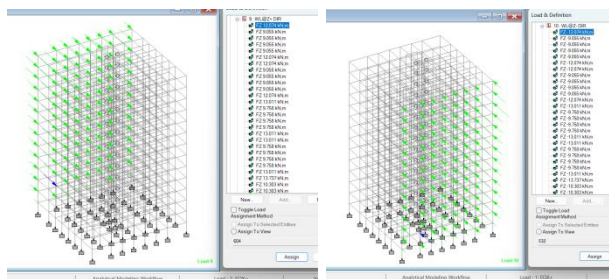


Fig-4 (b) Wind load in Z(+) & Z(-) Direction

## WIND LOAD ACTING IN RECTANGULAR BUILDING IN EVERY DIRECTION

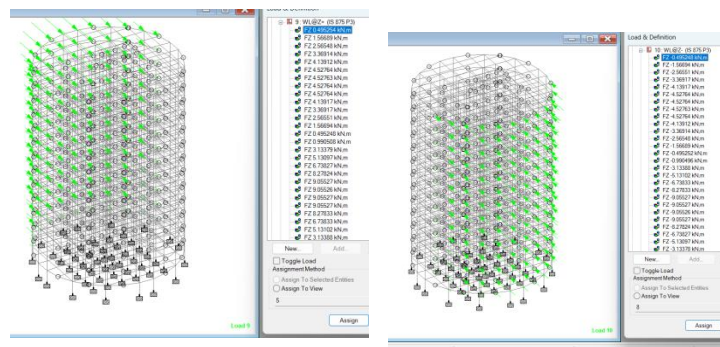


Fig-4 (d) Wind load in Z(+) & Z(-) Direction

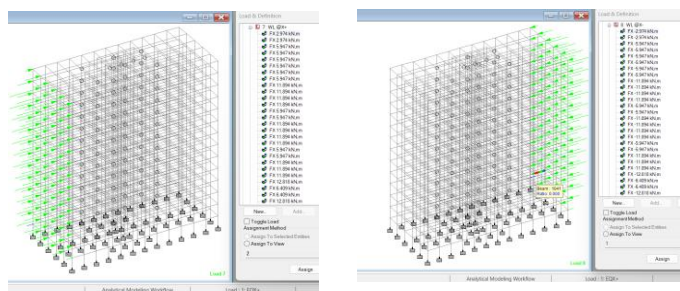


Fig-4 (c) Wind load in X(+) & X(-) Direction

## H. DESIGN BASIS

Design wind loads for the square, rectangular, and circular G+12 reinforced concrete building models are determined in accordance with IS 875 (Part 3):2015, using the relevant wind speed and site and structural factors. The models are analysed under consistent conditions, and their lateral displacement, storey drift, base shear, torsional response, and fundamental time period are compared to assess how plan configuration affects wind-induced structural behaviour. The reinforced concrete members are designed in accordance with Indian Standard Code. Other relevant codes as mentioned in the list above were also followed for specific items of work.

### Grade Of Concrete And Cover To The Reinforcement.

The appropriate grade of concrete and nominal cover to reinforcement is governed by the

Following main considerations:

- Durability of Concrete
- Fire Resistance
- Corrosion Protection to the Reinforcement
- Bar Size
- Nominal maximum aggregate size
- Proposed Grade of Concrete & Cover to Reinforcement

## WIND LOAD ACTING IN CIRCULAR BUILDING IN EVERY DIRECTION

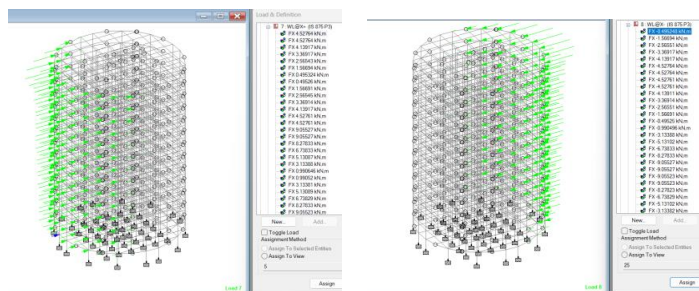


Fig-4 (e) Wind load in X(+) & X(-) Direction

Considering the nature of soil as observed in site during previous excavation for the site and the exposure conditions, fire rating, durability requirements etc. mentioned in IS Code, the proposed grade of concrete for all the reinforced concrete members is **M30**, and clear cover to Reinforcement for various items are as follows:

- |                         |      |
|-------------------------|------|
| • Roof and plinth Beams | 25mm |
| • Columns & Pedestals   | 40mm |
| • Slabs                 | 20mm |
| • Footings              | 50mm |
| • Raft                  | 75mm |

### Materials

- Materials used as constituents of concrete shall be as per clause of IS codes. The properties of hardened concrete shall be as per IS code and other relevant clauses shall be considered.
- Reinforcement
  - The following types of reinforcement bars shall be used:
    - Thermo-mechanically treated (TMT) Confirming to IS: 1786-1985 ( $f_y = 550$  MPa)
    - Deformed bar Confirming to IS: 1786-1985 ( $f_y = 415$  MPa)
  - Reinforcement Bars of size 8 mm, 10 mm, 12 mm, 16mm, 20mm, 22mm and 25mm will be used. Welded wire mesh shall not be used for structural members. Only lapped splices/Coupler shall be used.
- Admixtures
  - The concrete slump shall in general be in the range of 75mm and 125mm depending on reinforcement congestion, ambient temperature and other placement, transporting and compaction considerations.
- Cement
  - Use of Ordinary Portland Cement as per NBC is recommended for all elements of the structure is recommended.
- Structural Dimensioning
  - In addition to the requirements of loads and stresses the minimum structural dimensions are also governed by other considerations like fire resistance, size of aggregates, reinforcement detailing, etc. Minimum width of beams & columns shall not be less than 250mm from above requirements. The minimum thickness of any structural element shall conform to NBC. The minimum thickness of various elements shall also meet the fire resistance requirements of IS: 8110-Part 1-1985. All the reinforced concrete elements of the building will be designed for mild condition of exposure and a fire resistance of 1.5 hours.

### III. RESULT

#### 1. Maximum Node Displacement Comparison

TABLE 3: MAXIMUM NODAL DISPLACEMENT

| Parameter                           | Square Building | Rectangular Building | Circular Building | Best Performance |
|-------------------------------------|-----------------|----------------------|-------------------|------------------|
| Maximum X displacement (mm)         | 92.630          | 55.529               | 76.187            | Rectangular      |
| Maximum Y displacement (mm)         | 57.231          | 25.668               | 32.368            | Rectangular      |
| Maximum Z displacement (mm)         | 46.445          | 41.002               | 55.958            | Rectangular      |
| Maximum resultant displacement (mm) | 93.189          | 57.276               | 78.076            | Rectangular      |

TABLE 4: ROTATIONAL RESPONSE COMPARISON

| Parameter      | Square Building | Rectangular Building | Circular Building | Lowest Rotation |
|----------------|-----------------|----------------------|-------------------|-----------------|
| Maximum rX (°) | 0.083           | 0.113                | 0.138             | Square          |
| Minimum rX (°) | -0.083          | -0.113               | -0.138            | Square          |
| Maximum rY (°) | 0.022           | 0.017                | 0.022             | Rectangular     |
| Minimum rY (°) | -0.022          | -0.020               | -0.021            | Rectangular     |
| Maximum rZ (°) | 0.139           | 0.121                | 0.165             | Rectangular     |
| Minimum rZ (°) | -0.139          | -0.121               | -0.164            | Rectangular     |

TABLE 6: MAXIMUM RESULTANT DISPLACEMENT (MM)

|             |        |
|-------------|--------|
| Square      | 93.189 |
| Circular    | 78.076 |
| Rectangular | 57.276 |

TABLE 7: MAXIMUM REPORTED SUPPORT REACTION COMPARISON

| Parameter       | Square | Rectangular | Circular | Lowest      |
|-----------------|--------|-------------|----------|-------------|
| Maximum FX (kN) | 77.628 | 50.422      | 139.904  | Rectangular |
| Maximum FY (kN) | 4140   | 4200        | 4660     | Square      |
| Maximum FZ (kN) | 2640   | 2980        | 2810     | Square      |

TABLE 8: MAXIMUM SUPPORT MOMENT COMPARISON

| Parameter        | Square             | Rectangular        | Circular           | Lowest      |
|------------------|--------------------|--------------------|--------------------|-------------|
| Maximum MX (N-m) | $2.13 \times 10^6$ | $3.09 \times 10^6$ | $3.26 \times 10^6$ | Square      |
| Maximum MY (N-m) | $1.28 \times 10^6$ | $2.25 \times 10^6$ | $1.98 \times 10^6$ | Square      |
| Maximum MZ (N-m) | $116 \times 10^3$  | $74.2 \times 10^3$ | $353 \times 10^3$  | Rectangular |

#### IV. CONCLUSION

TABLE 9: PERFORMANCE AND CONCLUSION

| Performance Parameter       | Square | Rectangular | Circular | Best        |
|-----------------------------|--------|-------------|----------|-------------|
| Maximum X displacement (mm) | 92.630 | 55.529      | 76.187   | Rectangular |

|                                     |                    |                    |                    |             |
|-------------------------------------|--------------------|--------------------|--------------------|-------------|
| Maximum Y displacement (mm)         | 57.231             | 25.668             | 32.368             | Rectangular |
| Maximum Z displacement (mm)         | 46.445             | 41.002             | 55.958             | Rectangular |
| Maximum resultant displacement (mm) | 93.189             | 57.276             | 78.076             | Rectangular |
| Maximum rX (°)                      | 0.083              | 0.113              | 0.138              | Square      |
| Maximum rY (°)                      | 0.022              | 0.017              | 0.022              | Rectangular |
| Maximum rZ (°)                      | 0.139              | 0.121              | 0.165              | Rectangular |
| Maximum FX reaction (kN)            | 77.628             | 50.422             | 139.904            | Rectangular |
| Maximum FY reaction (kN)            | 4140               | 4200               | 4660               | Square      |
| Maximum FZ reaction (kN)            | 2640               | 2980               | 2810               | Square      |
| Maximum MX (N-m)                    | $2.13 \times 10^6$ | $3.09 \times 10^6$ | $3.26 \times 10^6$ | Square      |
| Maximum MY (N-m)                    | $1.28 \times 10^6$ | $2.25 \times 10^6$ | $1.98 \times 10^6$ | Square      |
| Maximum MZ (N-m)                    | $116 \times 10^3$  | $74.2 \times 10^3$ | $353 \times 10^3$  | Rectangular |

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