# RESPONSE ANALYSIS OF TALL STRUCTURE TO WIND LOADING WITH CRACKED SECTIONAL PROPERTIES

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**Abstract -** *As India experienced rapid development, cities will continue to see a huge spurt in the demand for housing and commercial real estate. Unlike low rise buildings, the design of taller buildings is driven not by gravity loads alone, lateral load such as wind and earthquake play a defining role in conceptualizing the design.*

*Due to the scarcity of land in big cities, architects often propose high-rise buildings to maximize the utilization of available floor space index (FSI). The tall building with an aspect ratio of more than 5 needs to be checked for the dynamic wind response. The structure that falls into this category may be subjected to crosswind oscillation and ovalling effect, besides, along with wind effect.*

*A study on the proposed building (Ground + 20 upper Floors + 1 Floor provision), located at Hinjewadi Phase 3, Pune is done. In the proposed study, 3 cases are considered namely, Case I - with no property modifiers, Case II - with SLS property modifiers, and Case III - with ULS property modifiers. An analysis is carried out in, commercially available FEA package ETABS, using static and dynamic analysis for wind loads. The guidelines laid by Indian Standard Code IS 875 (Part 3):2015, IS 1893 (Part 1):2016 and IS 16700:2017 will be used to compare the results. The results will be compared for parameters like base shear, deflection, storey drift, peak acceleration along with the wind, and across the wind, reinforcement percentage in columns at ground floor level.*

***Key Words*:** Cracked sectional properties, Gust factor, Peak acceleration, base shear, Deflection

## 1.INTRODUCTION

As India experienced rapid development, cities will continue to see a huge spurt in the demand for housing and commercial real estate. Unlike low rise buildings, the design of taller buildings is driven not by gravity loads alone, lateral load such as wind and earthquake play a defining role in conceptualizing the design.

In metropolitan cities land is scarce, to maximize the utilization of available land the architects often propose tall buildings.

The air in motion relative to the surface of the earth is wind. Which varies concerning time and space. Because of the erratic idea of wind, it is important to plan the tall structures by thinking about the basic impacts of wind on the structure. Wind force depends upon the exposed area of the structure which includes the shape and size of the structure also it depends upon the terrain and topography of the location where the structure exists, as well as the nature of wind and dynamic properties of the structure.

### 1.1 Modelling

The design of tall buildings is driven not by gravity alone, lateral load such as wind and earthquake play a defining role in conceptualizing the design. In this chapter various applicable clauses of IS 875(Part 3):2015, IS 1893(Part 1):2016 and IS 16700:2017 for the wind loading are given. Details of the simulation model in ETABS software package, inputs required for preparation of the model are provided and information regarding gravity loads, wind loads, etc. are given.

### 1.2 Simulation

In the proposed study 3 cases are considered namely;

a) Case I - With no modifiers
b) Case II - With SLS stiffness modifiers.
c) Case III - With ULS stiffness modifiers

ETABS analysis model is prepared for each case. The analysis is done, and torsional irregularity is checked. If there is torsion in the building the structural configuration is revised to ensure that the natural period of fundamental torsional mode of oscillation, shall be smaller than those of first two translational modes. Finally, the serviceability and strength checks are carried out and the results are compared as required.

### 1.3 Description of Building

The proposed building is in Hinjewadi phase 3, Pune, and is being developed by M/s Sansa developers, Pune. The proposed building will be used for residential purposes. The description of the building is given in table 1.

**Table -1:** Description of building

| | |
|---|---|
| Total No. of floors | Parking floor + 20 floors + 1 floor provision + Terrace floor |
| Numbers of parking floor | 1 Parking floor (at Ground level) |
| Height of the parking floor | 7.3 m |
| Numbers of residential floor | 21 no's (1st to 21st floor) |
| Height of residential floor | 2.9 m |
| The total height of the building | 71.1 m (From natural ground level to terrace Level) |

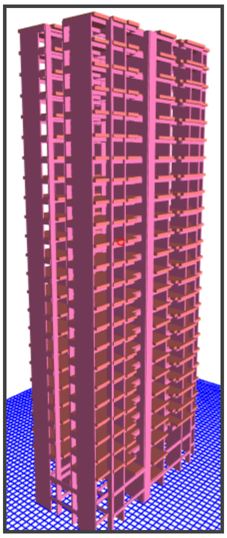

**Fig -1**: ETABS 3-d analysis model

### 1.4 Cracked Section Properties

As the structural members are designed as per limit state method the concrete member is considered as a cracked member. To consider the effect of cracking stiffness modifiers are used. The stiffness modifiers used are given in table 2.

**Table -2:** Cracked sectional properties

| Sr. No | Structural Elements | Un-Factored loads | | Factored loads | |
|---|---|---|---|---|---|
| | | For Serviceability | | For Strength | |
| | | Area | Moment of Inertia | Area | Moment of Inertia |
| 1 | Slabs | 1.0 Ag | 0.35 Ig | 1.0 Ag | 0.25 Ig |
| 2 | Beams | 1.0 Ag | 0.70 Ig | 1.0 Ag | 0.35 Ig |
| 3 | Columns | 1.0 Ag | 0.90 Ig | 1.0 Ag | 0.70 Ig |
| 4 | Walls | 1.0 Ag | 0.90 Ig | 1.0 Ag | 0.70 Ig |

### 1.4 Input Data

The information required for the preparation of ETABS model is as follows,

1. Description of building
2. Floor plans
3. Beam parameters
4. Slab parameters
5. Concrete properties
6. Reinforcement properties
7. Fire rating of the building
8. Nominal covers
9. Environmental exposure conditions
10. Load cases
11. Load combinations
12. Gravity loads
13. Wind loads
14. Seismic loads
15. Scale factor
16. Cracked sectional properties
17. Gust factor and Gust loads calculation

## 2. RESULTS

For the proposed study, the following results will be examined and will be compared to come to the conclusions,

1. Scale Factor
2. Displacement for wind loads
3. Acceleration of building

### 2.1 Scale factor

A scale factor is a coefficient used to enhance the base shear value of the response spectrum method to match with base shear calculated as per the equivalent static method. The scale factor used in each principal direction is given below.

$$\text{Scale X} = \frac{\text{Vbx (static)}}{\text{Vbx (dynamic)}}$$

$$\text{Scale Y} = \frac{\text{Vby (static)}}{\text{Vby(dynamic)}}$$

**Table -3:** Scale Factor

| Sr. No | Case No | X-direction | Y-direction |
|---|---|---|---|
| 1 | Case I | 2.432 | 1.615 |

| | | | |
|---|---|---|---|
| 2 | Case II | 2.778 | 1.718 |
| 3 | Case III | 3.335 | 1.781 |

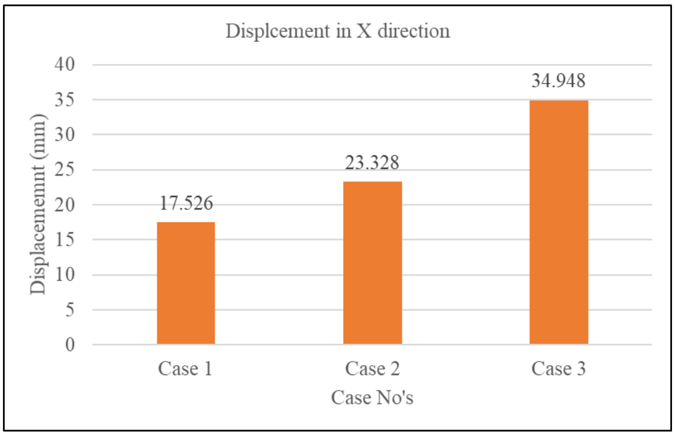


**Chart -1**: Displacement in X direction

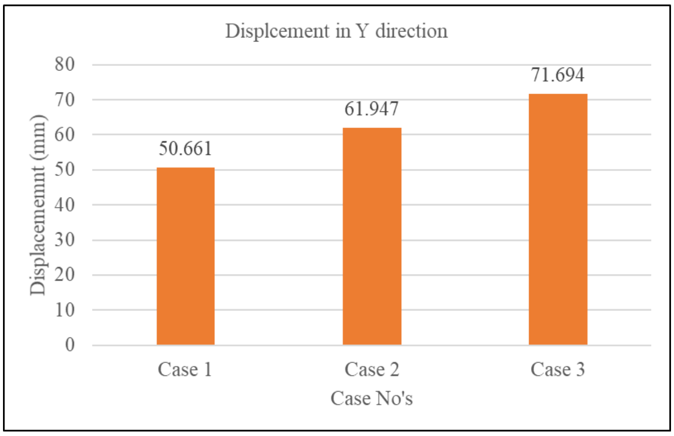


**Chart -2**: Displacement in Y direction

**Table -3:** Acceleration of building (m/s²)

| Sr. No | Case No | X-direction | Y-direction |
|---|---|---|---|
| 1 | Case I | 11.12 | 23.14 |
| 2 | Case II | 13.26 | 25.9 |
| 3 | Case III | 16.42 | 28.55 |

## 3. CONCLUSIONS

This study presents a response analysis of the tall structure to wind loading with cracked sectional properties. The conclusion is summarized below.

1. Scale factor increases in both directions with the use of stiffness modifiers.
2. Displacement is increased in both directions with the use of stiffness modifiers. The displacement values for all the cases are with codal limit.
3. Building acceleration is increased in both directions with the use of stiffness modifiers, acceleration exceeds the codal requirement for all the cases.

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