STUDY ON THE EFFECT OF GUST LOADS ON TALL BUILDINGS

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INTRODUCTION

High-rise buildings having very large number of stories are being constructed in urban towns and cities all over the world and India is also exception phenomenon. Tall buildings consisting of multi-storied framework are flexible in nature and they are susceptible to action of wind forces. In this introduction chapter the advent of multistoried buildings, the importance of wind loads, etc., are discussed here in.

Due to influx of heavy population the towns and cities are growing very rapidly. This phenomenon can be seen all over the world. The paucity of available land for construction particularly in major cities all over is a common problem.
A tall building means which consists of 6 to 100 stories or more. But to construct these, enormous cost in involved. For middle level cities, the number of stories can range from 6 to 12 with an upper limit of 12. For middle level cities casting a frame with concrete, say M25 of M30 can be done through conventional methods and with better supervision.

**LITERATURE REVIEW**

The various structural systems adopted for the construction of tall buildings, the wind loads on tall buildings, wind effects on static and dynamic structures, etc., are reviewed. The nature of wind the computation of design wind pressure the various factors required for computing the design wind pressure, etc., are reviewed.

**WIND LOADS ON TALL STRUCTURES**

The development of modern materials and construction techniques as resulted in the emergence of new generation of structures

<table>
<thead>
<tr>
<th>Story Level</th>
<th>Height in m</th>
<th>Axial Load (x-axis)</th>
<th>Axial Load in KN for Hyderabad</th>
<th>Axial Load in KN Ahmedabad</th>
<th>Axial Load in KN Delhi</th>
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</thead>
<tbody>
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<td>559.01</td>
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<td>71.37</td>
<td>71.86</td>
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</table>

**Figure 1: Variation of Axial Load with Height for Left End Column for 20 Storied Frame**
that are often, to degree unknown in the past, remarkably flexible, low in damping, and light in weight.

To achieve this end designer needs information regarding

• The wind Environment.
• The Relation between Environment and the forces induces on the structure.
• The Behavior of these structures under these forces.

**GUST EFFECTIVENESS FACTOR METHOD**

The procedure outline under design of wind speed is applicable to static or rigid structures for the computation of wind loads. The code also (IS: 875 PART-III) has described the gust effectiveness factor method, which is more applicable to deal with tall, slender and flexible structures. The details of gust effectiveness factor method are discussed here in.
Table 3: 60 Storey Frame (Dl+Ll+Wi) Left End Column

<table>
<thead>
<tr>
<th>Story Level</th>
<th>Height in m</th>
<th>Axial Load in KN for Hyderabad</th>
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<th>Axial Load in KN for Delhi</th>
<th>Axial Loads (x-axis)</th>
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</table>

Figure 3: Variation of Axial Load with Height for Left End Column for 60 Storied Frame

Only the method of calculation of load along wind or drag load by using gust factor method is given in the code since methods for calculating load across wind or other components are not fully matured for all types of structures. However it is permissible for a designer to use gust factor method to calculate all components of loads on a structure using any available theory. Use of existing theories of gust factor method requires knowledge of maximum wind speeds averaged over one hour at a particular location.
Table 4: 80 Storey Frame (Dl+LI+WI) Left End Column

<table>
<thead>
<tr>
<th>Story Level</th>
<th>Height in m</th>
<th>Axial Load in KN for Hyderabad</th>
<th>Axial Load in KN for Ahmadabad</th>
<th>Axial Load in KN for Delhi</th>
<th>Axial Loads (x-axis)</th>
</tr>
</thead>
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</tr>
</tbody>
</table>

Figure 4: Variation of Axial Load with Height for Left End Column for 80 Storied Frame

DETAILS OF FRAMES ANALYZED AND WINDLOAD COMPUTATIONS

The code of practice for design loads IS: 875 PART-III-1987 has given gust effectiveness factor method for estimating the wind load. To study the criticality of wind loads obtained by gust effectiveness factor method for the design of tall buildings.

In gust effectiveness factor method, wind
pressures are obtained directly from wind velocity which depends on factors like terrain, topography, size and dynamic properties like stiffness, damping, fundamental frequency, background factor, etc., are taken into account for obtaining wind pressures. In the present project work, typical multi storied building ranging from 20 to 80 storeys are examined for criticality of wind loads in typical places like Hyderabad, Ahmedabad and Delhi.

**DESCRIPTION OF STAAD-PRO**
- Computer is a major invention of the 20th Century. Over the years, they have invaded
all the walks of life. Computers have entered almost all the engineering field.

- Using STAAD-PRO software package we can do both static and dynamic analysis of structure. Earlier Civil engineers used flexibility and stiffness method for analysis and designing.

### Analysis Facilities
Following Analysis facilities are available in STAAD-PRO

- Stiffness Analysis
- P-Delta Analysis
- Dynamic Analysis
Salient feature of stiffness analysis, which is being used in this work, has been discussed in the following sections.

**Stiffness Analysis**

- The stiffness analysis implemented in STAAD-PRO is based on the matrix displacement method.
- In the matrix analysis of complex structures by the displacement method, the structure is first idealized into an assembly of discrete structural elements.
- Each element has an assumed form of displacements in a manner, which satisfies the force equilibrium and displacement compatibility at the joints.

**Assumption of the Analysis**

For a complete analysis of the structure, the necessary matrices are generated on the basis of the following assumptions:

- The structure is idealized into an assembly of beam and plate type elements jointed together at their vertices (nodes). The
Figure 8: 40 Storey Frame with Shear, Bending and Displacement

assemblage is loaded and reacted by concentrated acting at the nodes. These loads may be both forces and moments, which may act, in any specified directions.

- A beam member is a longitudinal structure member having a constant, doubly symmetric near-doubly symmetric along its length. Beam members always carry axial forces.
• A plane element is a three or four nodded element having constant thickness. These plate elements are referred to as “elements” in the manual.

• Internal and external loads are acting on each node are in equilibrium. If torsional or bending properties are defined for any member, six, degree of freedom are
Figure 10: 60 Storey Frame with Shear and Bending Moment
Figure 11: 80 Storey Frame with Wind Loads and SWAY Moment

PRESENTATION OF RESULT ANALYSIS

Results Presented
The present thesis covers the study of variation of gust pressures in tall multi storied frames and their effects on the members of the frames. The various results of columns moments, column axial forces, beam moments, etc., are tabulated for three different wind climates of the country. Multi storied frames with height varying from 20 to 80 stories are covered in this analysis. For the analysis in tall cases, gust

considered on each node (Le. Three transnational and three rational) in the generation of relevant matrices.
Figure 12: 80 Storey Frame with Shear and Bending Moment

Whole Structure Mz 100kN/m:1m Pz 100kN:1m Fy 100kN:1m 3 1.2(DL+LL+WL)
loads computed by using gust effectiveness Factor method as per IS: 875 PART-3.

DISCUSSION

- As the number of stories of a multi storied building frame increases the slenderness of the frame also increases. The building frame becomes more and more flexible with height.
- If the height of building frame id limited with larger aspect ratio, the frame tense to be rigid.
- In the case of rigid structures the natural frequency of building frame is very high and hence it does not dynamically interact with the fluctuating wind component.
- The frame dynamically interacts with the fluctuating wind component and as a result critical wind effects is more appropriate and realistic for computation of equivalent static wind loads on the structure.

CONCLUSION

- Gust effectiveness factor method, which is rational and realistic, should be considered for the computation of wind loads in the case of very tall frames and structures. It becomes necessary to study the criticality of wind forces in the case of multi-storied frames particularly on more serve wind zones.
- In the very tall frames it is necessary to combine the effect of lateral wind Load to examine the net axial force in the extreme end column to know its stability. In a place Hyderabad there is a reduction by 71% in the left end column axial force for a 20-storey frame. Similarly the reduction increases further for 40, 60 and 80 stories frames. In a place like Ahmedabad there is a reduction by 59% in the left hand column axial force for a 20-storey frame. Similarly the reduction increases further for 40, 60 and 80 stories frames. In a place like Delhi there is a reduction by 80% in the left hand column axial force for a 20-storey frame.
- For the design of columns both axial loads moments critical for design when wind effects are included.
- The values of beam moments increase by 20 to 35% bottom to top for different multi-storied frames from 20 to 80 stories for dead load and live load combination. Large criticality is being caused in the design of beams in multi-storied frame when wind effects are included.
- There is need to considered the wind effects in the case of frames having more than 20 storey particularly in serve wind climate to arrive at the critical values for design.

SUGGESTIONS FOR FUTURE WORK

- It has been established that wind causes criticality in the design of tall frames and structures, which are flexible in nature. The present project work covers the tall multi-storied frames.
- Further work may be carried out on tall structure like steel towers, chimneys, cooling towers, etc., for wind effects. Frequency analysis may be carried out to know their dynamic behavior.
- Criticality between wind and earthquake may be examined.
REFERENCES


