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STUDY OF RESPONSE OF SQUARE SHAPE TALL BUILDING UNDER WIND LOADS USING IS-CODE METHOD AND EXPRIMENTAL METHOD

Mohd Shariq[*1], Dr. Ritu Raj [2]

M Tech Scholar, Department of Structural Engineering, Mewar University, Chittorgarh, India[1]

Faculty, Department of Structural Engineering, Mewar University, Chittorgarh, India[2]

Abstract: Many constructions that are being constructed at present tend to wind-sensitive because of their shapes, slenderness, flexibility, size and lightness. This leads to demands for economical wind resistant designs. In the designs of high-rise buildings, lateral loads like wind and earthquake forces play a significant role in the stability of the structure for. In the present study only wind effects on tall buildings are studied. Wind loading on the basis of wind tunnel tests is carried out on square shaped building model with uniform cross-section along the height given for different building models. In present study, square shape is considered. The present study is carried out under two major heads namely: (i) Experimental study and (ii) Response study.

In the experimental study, the rigid model of the tall buildings with square is tested in boundary layer wind tunnel in order to find mean and fluctuating pressures at various points in different surfaces. Square shape models are tested in open circuit wind tunnel in which small blocks are used as the obstruction to meet the wind tunnel simulation requirement and for the development of turbulent flow for generating the atmospheric surface layer in the 2mX2m cross section at wind tunnel. The effects of shape of the building model on the wind pressures distribution are also discussed. The second part of the present study is to carry out study to obtain response of the building having square shape by using wind loads obtained experimentally in part one. Prototype buildings are assumed to be made of RCC beams and columns with grid size 20mX20m and story height 3.75m (ground floor) and 3.125m (remaining 18 floors).

The buildings are analyses by readily available software package STAADPRO. Mean response including moment about axis, shear force, twisting moment and displacement are obtained under wind incidence angle in order to study the effects of square shape under wind loads.

Keywords: RCC, STAADPRO.

I. INTRODUCTION

Wind is the movement of air which occurs naturally in to the atmosphere. It is usually applied to the natural horizontal motion of the atmosphere. The design of the building is dependent upon various functions i.e. utility of building, safety of structure, ventilation, fire safety and sanitation. To fulfill those functions all the forces come into action are considered in which the effects of wind on tall buildings plays a vital role.

As the building experiencing wind effect some problems occurs such as vibrations of various hangings and lightweight objects, open doors and windows may swing and may fall. In case of heavy storms it may create safety hazards also. Various types of structure are there in civil engineering upon which wind effects are calculated such as Tall Buildings, Chimneys, Long Bridges and Transmission Towers. When the wind interact with the structure, it creates pressure on the surface and subjected to force caused due to wind, these forces are called as wind load which in turn exerts positive pressure along the direction of wind called as drag force and negative pressure (suction) on opposite face termed as lift force or across wind response and side responses (transverse load). The across wind response is larger than the along wind response. Due to this combination of responses a building can vibrate torsianally due to random effect of wind.

The effect of wind to the structure depends upon characteristics of wind and different flow situation arises from interactions of building with structure. The characteristics of wind are velocity with different height, turbulence, wind-structure interaction and vortex flow of wind.

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Wind load is getting reduced with increase in height, the maximum height at which the horizontal airflow is no longer influenced by ground effect called as Gradient Height. Wind is fluctuating in nature and the variation in speed of wind is called as gust or turbulence.

II. MATERIALS AND METHODS

METHOD OF EVALUATION OF WIND LOADS:

Wind loads are calculated by using two following methods:

1) Pressure co-efficient method
2) Force co-efficient method

Pressure Co-efficient Method:

Wind has two components one is static and other is dynamic. The intensity of pressure acting on the building depends upon the size of building, shape of building, terrain and topography present at site. Pressure co-efficient is different for different surface conditions. Pressure co-efficient is used to determine the design wind pressure. As the wind is fluctuating with hence, the Pressure co-efficient can be treated as time varying quantity.

ForceCo-efficient Method:

Force coefficients method is used for calculating horizontal motion of wind on structural frames that can be determining by the difference between the wind pressure coefficients on front and opposite faces of the building. Likewise, the wind force coefficients CR for calculating roof wind loads on structural frames are givenby the difference between the external and internal pressure coefficients, Cpe and Cpi , on the roof. The value of force co-efficient is applied on a structure as a whole. The total wind load on particular structure or building can be written as follows:

$$F = Cf * Ae * Pd$$

Where,
F = wind load;
Cf = force coefficient
Ae = effective frontal area;
Pd = design wind pressure.

CALCULATIONS OF WIND LOAD

The wind loading is given in terms of pressure coefficients Cp and force coefficients Cf can be determined as follows:
$F = Cf * Ac * Pd$
$F = (Cpe - Cpi) * A * Pd$
F = wind load;
Cf = force coefficient
Ae = effective frontal area obstructing wind, which is identified for each structure;
Pd = design wind pressure;
(Cpe -Cpi) = external and internal pressure coefficients;
A = surface area of structural elements.
As per IS : 875 (Part – 3) – 1987,

Design wind speed is given by :
$Vz = Vb*k1*k2*k3$
Vb = Basic Wind Speed
k1 = Probability Factor (or) Risk Coefficient
k2 = Terrain and Height Factor
k3 = Topography Factor
Design wind pressure is given as:
$Pd = 0.6 Vd^2$

In the present study experimental values of pressures are obtained by wind tunnel experiments which are directly used for calculations of forces acting on the prototype.

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DETAILS OF MODEL

Square shaped model:

One model of square shape building is used for experiment study. Model is made of (6 mm thickness) which is used for pressure measurement.

The square shape model is made in the geometrical model ratio of 1:200. An open terrain wind tunnel classified as terrain category-2 was simulated using a set of small cubical blocks and roughness elements placed upstream of the building model inside the wind tunnel.

Dimension of model
Height of model – 600 mm
Length and Width – 200 mm

The model is instrumented with 140 numbers at pressure taps at seven different height levels around the model surface to obtain a good distribution of pressure on all the faces of the model. The pressures taps are connected by plastic tubes to miniature electronics pressure transducers which can measure the fluctuating pressures.

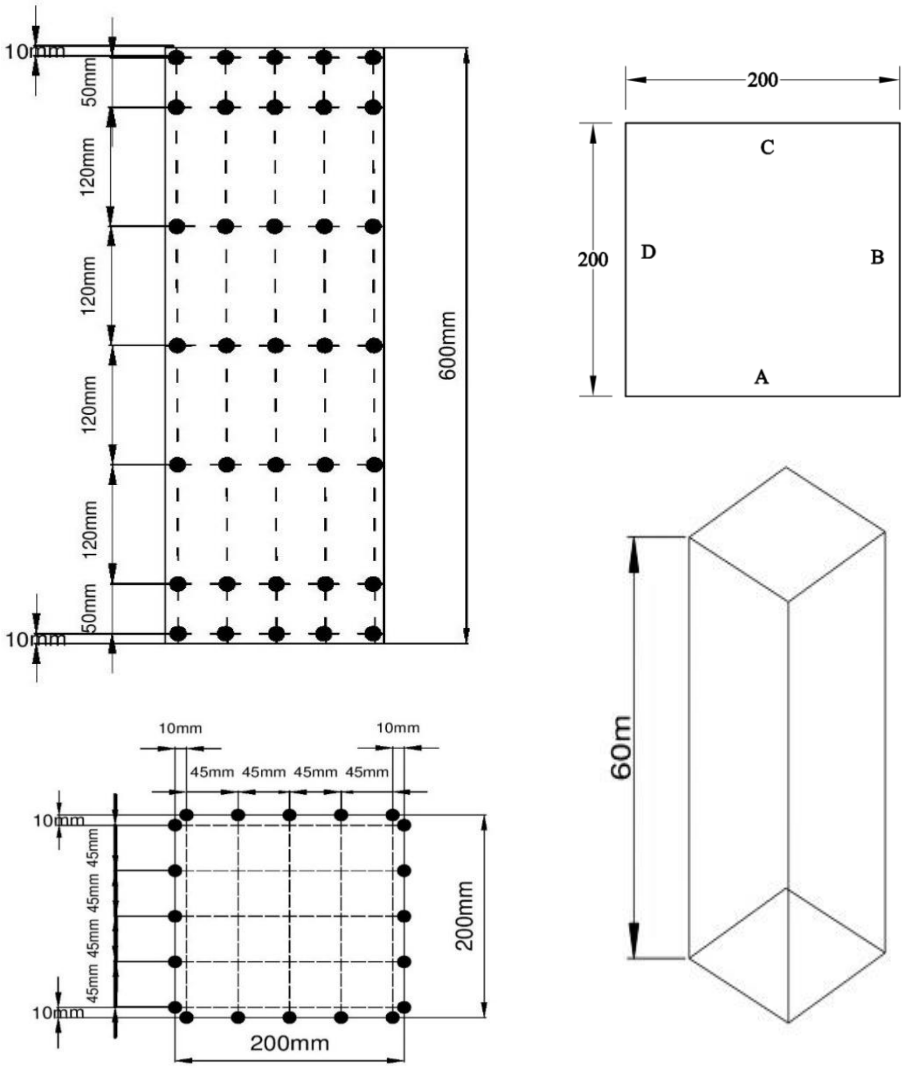

Fig. 3.1 Details of pressure points on Square shape model

(All dimensions are in mm)

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DETAILS OF WIND TUNNEL

As mentioned earlier, the fluctuating pressures at each pressure point are measured using baratron pressure gauge for duration of 60 seconds. The readings measured at each point are in the form of **mmhg**. All readings recorded from the Baratron pressure gauge are multiplied with some multiplying factor to convert it into the pressure (N/m^2).

Values of pressure measured at all pressure points for duration of 60 seconds are averaged to get mean wind pressure.

Figure: In-side view of wind tunnel showing flow roughening devices

EVALUATION OF PRESSURES

As mentioned earlier, the fluctuating pressures at each pressure point are measured using Baratron pressure gauge for duration of 60 seconds. The readings measurement at each point are in the form of **mmhg**. All readings recorded from the Baratron pressure gauge are multiplied with some multiplying factor to convert it into the pressure (N/m^2).

III. RESULTS AND DISCUSSION

Base Moment (Mx) about x- axis in Column E

Fig.shows the moment about 'X' axis (Mx) for 0˚ incidence angle. It is seen that the maximum Mx is always observed at base of tall building in different wind incidence angle. Maximum base moment (Mx) in this column in experimental method & IS Code method are 14830 KN-m and 23340 KN-m respectively. Hence, while comparing, it is observed that the value of Mx in IS Code method is 36% greater than the value of Mx in experimental method.

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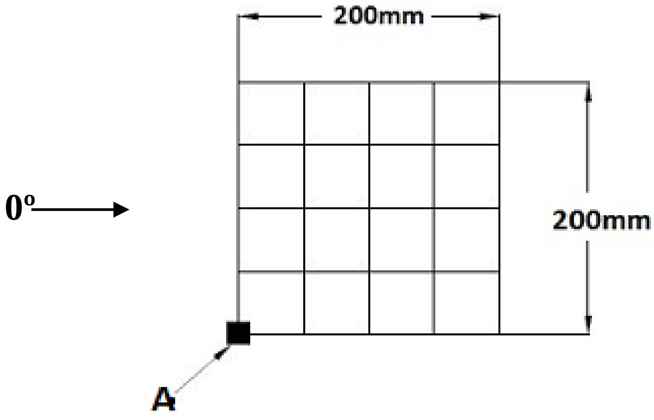

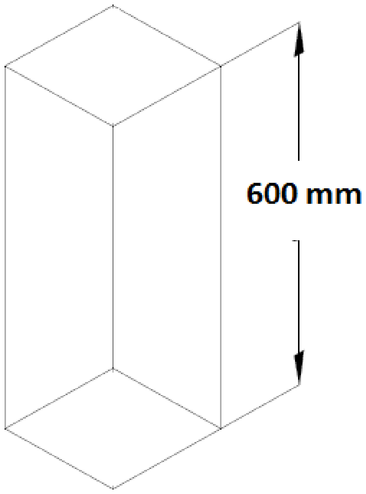

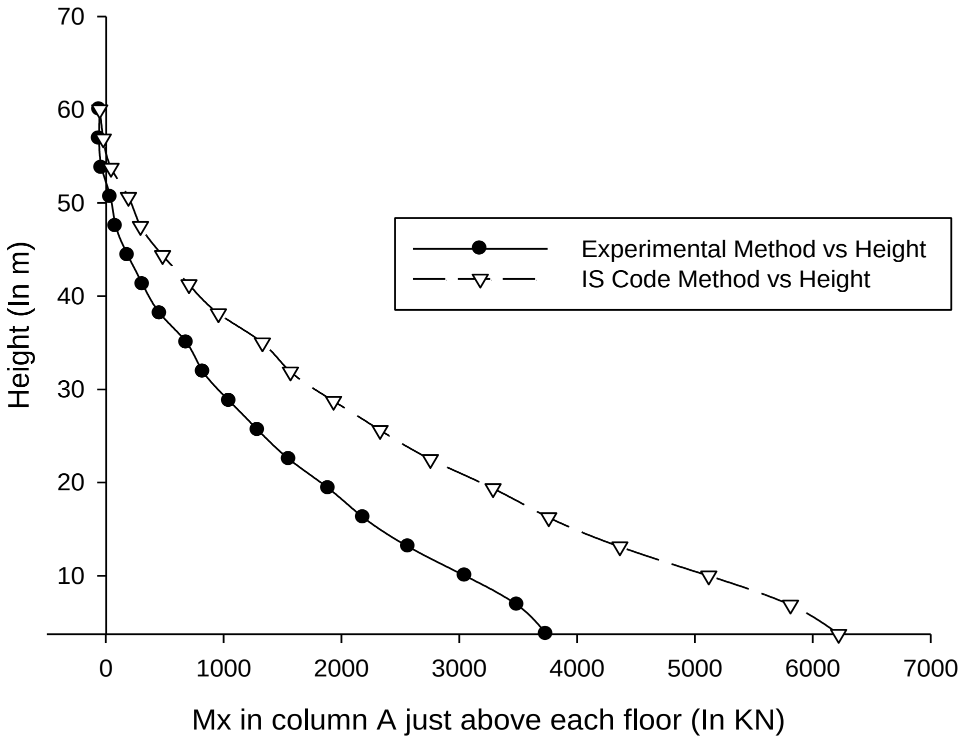

Fig. Effect of 0˚ wind incidence angle on Base Moment (Mx) in Column A

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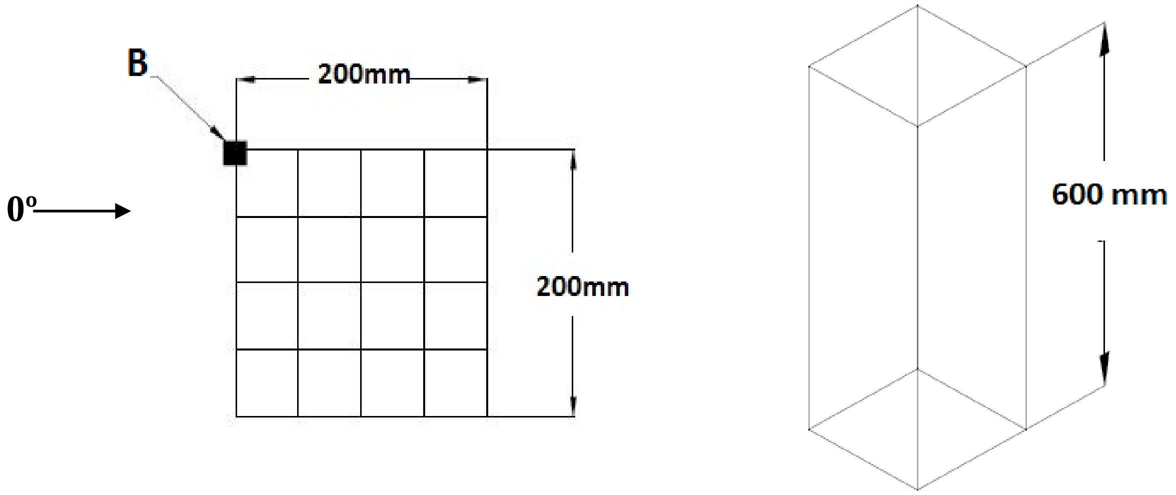

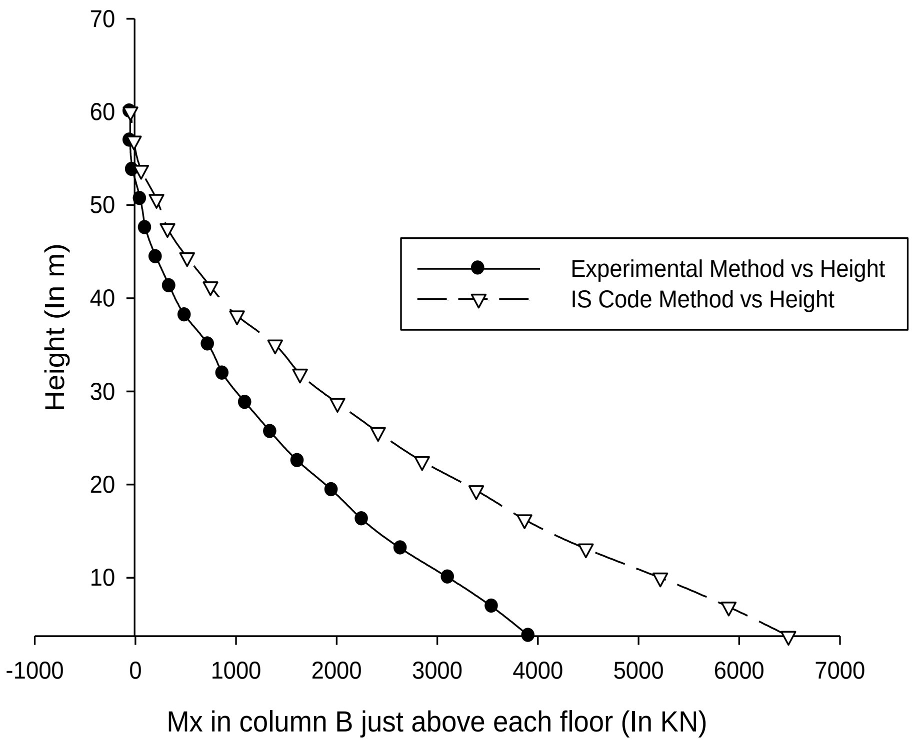

Fig. Effect of 0° wind incidence angle on Base Moment (Mx) in Column B

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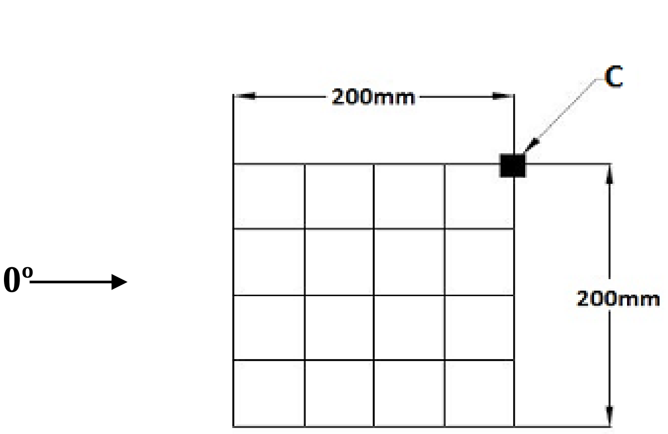

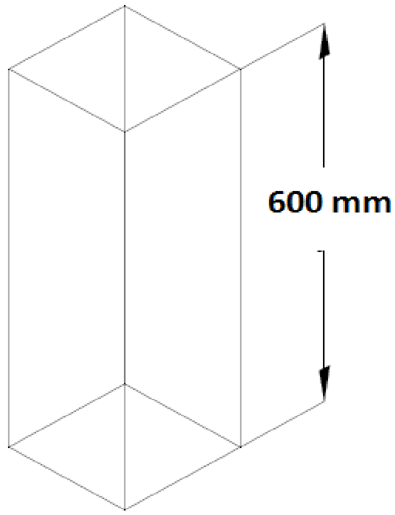

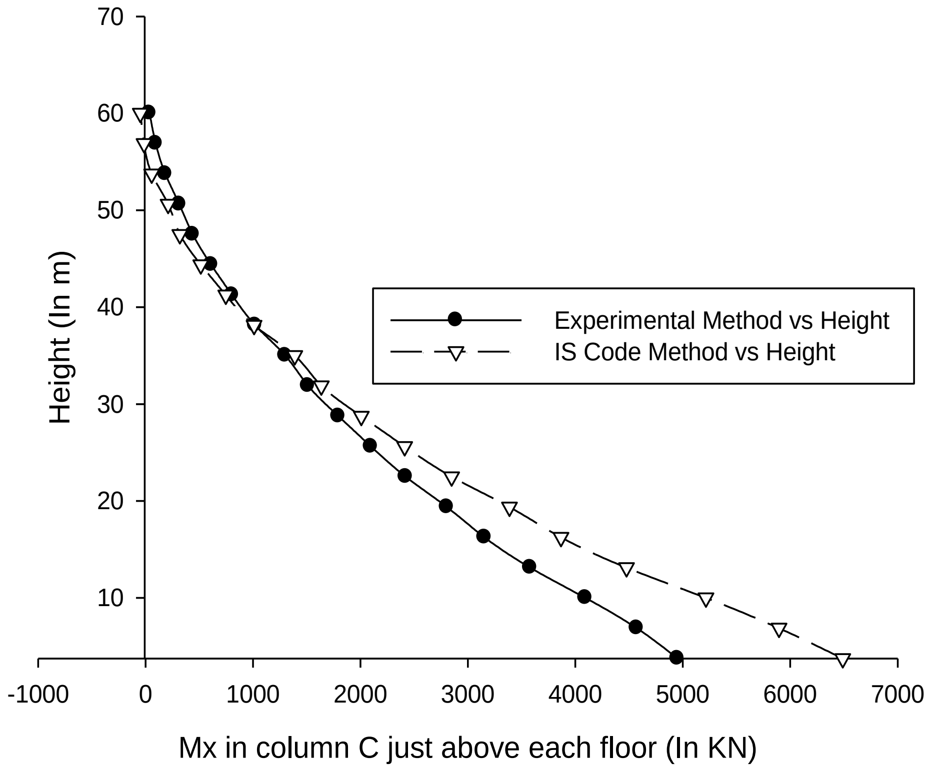

Fig. Effect of 0° wind incidence angle on Base Moment (Mx) in Column C

IV. CONCLUSION

The preceding chapters of this thesis cover a detailed study on the effects of wind on tall buildings with different cross-sectional shapes. In the experimental study, models made of Perspex sheet are used for pressure measurement. Response study is carried out to compute the response of these buildings under experimentally obtained wind loads.

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Significant findings of the present study are summarized below.

AXIAL FORCE IN COLUMNS

i. In case of Column - C & D, the axial force is almost double as compare to Column A & B respectively.
ii. In Column A, in experimental study negative axial force observed between height of 30m to 60m at small extant while in case of IS Code method it occurs between 45m to 60m.
iii. In experimental study, Column-B experienced less axial force i.e. 610 KN.
iv. In case of central most column the effect of wind load on axial force is almost equal in experimental study as well as in IS Code method.

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