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WIND ANALYSIS ON A RECTANGULAR BUILDING MODEL

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ABSTRACT—In the fast growth of urbanization and rapid development of the construction industry tall buildings are rapidly increased. Wind loads are one of the vital governing loads in the design of such tall buildings. The primary purpose of this work is to understand and quantify the effects of aerodynamic characteristics on tall building models for wind loads, under uniform flow condition. This paper is concerned with wind pressure analysis on a rectangular building model of size 8cm×16cm×24cm with an aspect ratio of 1:2:3 at three different levels over the height for 00 angle of wind incidence with different wind speed of 15m/s,20m/s and 25m/s. The drag coefficient and pressure coefficient are obtained from the pressure coefficients by the numerical integration method. These results will help the engineers to design the building in conservative way. The results obtained in this present work can be adopted for real life structure by multiplying with the scale factor if the conditions are well suited with the experiments.

INDEX TERMS— drag coefficient, aspect ratio, pressure coefficient, scale factor

I. INTRODUCTION

The development of new materials and advanced construction techniques in recent years has resulted in the emergence of many tall buildings, which are generally wind-sensitive, in the urban environment. The assessment of wind loads on such tall buildings becomes necessary for their design. For the evaluation of wind loads, IS 875 (Part 3)-1987 provides pressure/force coefficients, which are based on wind tunnel studies on building models under uniform flow conditions. Further, these coefficients are available for only selected geometrics and selected wind speed incidence. The current code specify only provision for calculating wind load by pressure/force coefficients for specified wind flow speed and specified terrain conditions flow condition.

Katagiri et al. (2001) observed that the characteristics of motion-induced modal wind force acting on a high-rise building with a side ratio of 2 during turbulent flows are different from those during a uniform smooth flow. Liu et. al. (2013) studied span wise correlation of aerodynamic forces on a 5:1 rectangular cylinder through wind tunnel test in smooth flow at 0° angle of wind incidence. Abraham et.al. (2013) presented a wind tunnel study on a 1:300 scale model of a tall building with unconventional plan shape for evaluation of mean force coefficients under isolated and interference condition and also the effect of interference were studied. Wind pressure measurements for estimating instantaneous base-shear forces and torsional moments on building models with same plan dimensions (aspect ratio of 1.6) were carried out in a boundary-layer wind tunnel for open terrain for different wind directions by Elsharawy et. al. (2013).Anila Jayakrishnan et.al. (2014) reported a wind tunnel pressure measurement studies on a 1:2:3 rectangular scaled building model under boundary layer flow of suburban terrain condition of 15 m/s wind speed for 00 angle of wind incidence. K S Priyanga et.al. (2014) presented a wind tunnel pressure measurement on a 1:2:7 rectangular building model at 12 different angle of wind incidence at a wind velocity 11.5 m/s.

However, the reported studies on rectangular building models under uniform flow conditions of various wind incidence speed are observed to be scarce in literature. In the present study, wind analysis on a 1:2:3 rectangular building model have been carried out under uniform flow conditions of various velocities. The measured pressures on the building model have been analyzed to obtain mean values of pressure coefficients and drag coefficients.

II EXPERIMENTAL SETUP

A. Wind tunnel facility

The present study was conducted in the uniform flow wind tunnel facility available at MAM School of Engineering, Trichy. The wind tunnel is low speed subsonic. The axial fan drive is 4 and the contraction area of the wind tunnel 9:1.The cross section is 0.3 m x 0.3 m with adjustable side walls. The present study was conducted in the upstream side of the test section, where the flow is uniform in nature. The speed of the wind tunnel is 48 m/s.

B. Details of Model

For the present pressure measurement study, rigid type model was considered. The rectangular building model has been fabricated with 1:2:3 proportions, i.e.8 cm x 16 cm in plan and height of 24 cm, by using wood of 5 mm thickness. Pressure ports of diameter 4 mm were drilled along the circumference of the rectangular building model at 3 different levels (Level 1 to Level 3) 4 cm, 12 cm, and 20 cm, respectively. Figure 1 and 2 shows the schematic diagram of the model with locations of pressure ports. It can be seen that a total number of 16 pressure ports are provided at each level.

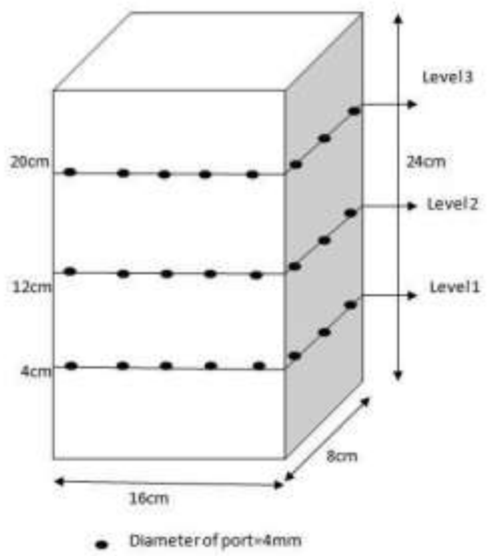

Figure1. Schematic view of elevation of rectangular model with instrumented level

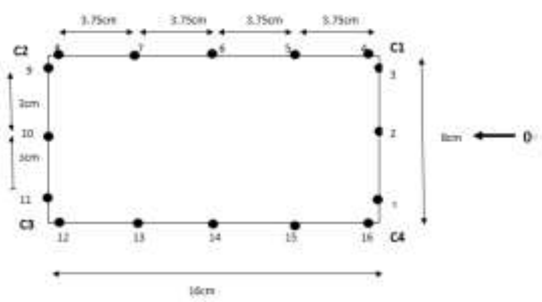

Figure2. Schematic diagram of the plan of rectangular building with pressure tap location

C. Pressure measurements

In the present study, the instrumented building model was mounted in the test section of the wind tunnel to measure the wind induced pressures under uniform flow condition. The pressure measurement studies were conducted at a wind speed (*U*) of 15 m/s, 20m/s and 25 m/s for 00 angle of wind incidence. Fig. 3 shows typical views of the instrumented building model inside the wind tunnel.

Figure3. Typical views of the instrumented building model inside the wind tunnel.

III RESULTS AND DISCUSSIONS

The measured pressure data has been processed to evaluate aerodynamic pressure and force coefficient. From the evaluated pressure and force coefficients, mean values have been calculated and are reported in this paper.

A. Pressure coefficients

The Pressure coefficients are always given for a particular surface or part of the surface of a building Pressure coefficients are commonly based on the quasi – steady assumption, whereby the pressure coefficient is taken to be the ratio of mean pressure measured over a point or pressure averaged over a small tributary area divided by the dynamic pressure (0.5* ρ V2)
Win Here ρ is the mass density of air and V the wind speed.

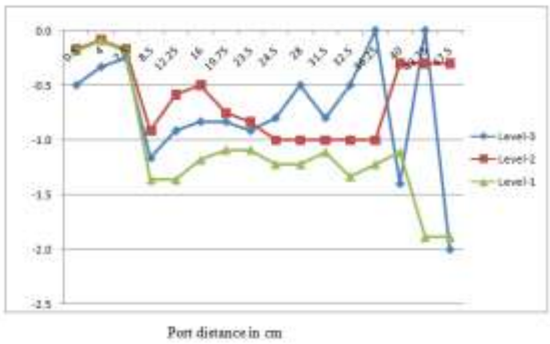

Figure4. Cp distributions along chord length for 15 m/s wind incidence

As we can see from the plot, the mean pressure coefficient distributions for Level 1to Level 3 are comparable on the windward face (chord length from 0 to 8 cm), whereas for Level 1 the values are comparatively higher and this could be due to the increased velocity, which might be due to increased edge effect near the ground surface. Likewise, at Level 1 the suction pressure coefficient on the side faces (chord length between 8 cm to 24 cm and 32 cm to 48 cm) are also seen to be considerably more for the first level as compared to other levels. However the distributions for all levels on the leeward side (chord length between 24 cm to 32 cm) are comparable and so we can say that the edge effect due to ground surface is negligible for leeward side.

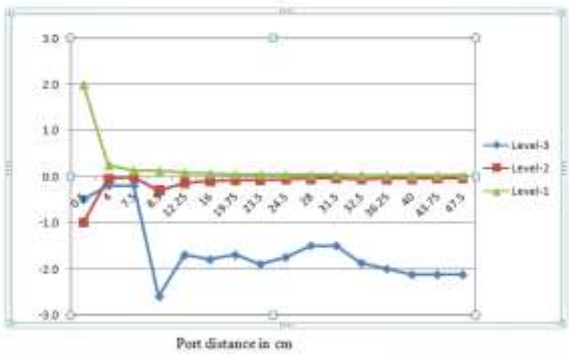

Figure5. Cp distributions along chord length for 20 m/s wind incidence

The distributions for all levels on the windward side (chord length in between to 8 cm) are comparable and so we can say that the effect due to wind force on 3 levels is high.

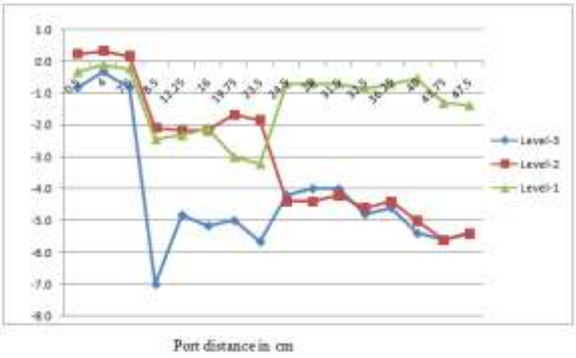

Figure6. Cp distributions along chord length for 25 m/s wind incidence

In the pressure distribution plot for 25 m/s wind speed is comparatively very high on suction side (chord 8 cm to 24 cm and 32 cm to 48 cm).

B. Drag coefficients

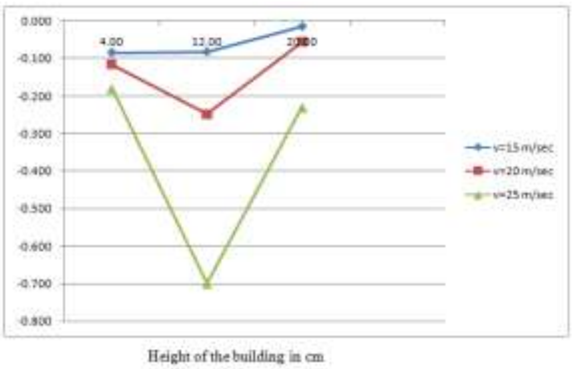

Figure7. Mean Cd distributions along chord length for various wind speed

The following plot Fig.7 gives the variation of mean drag coefficient distribution around the chord length of model at different levels with different velocities.ie corresponding to Level 1 to Level 3 along the height of the model for 0° angle of wind incidence. In the above plot, mean drag coefficient distributions for different velocities show a similar trend as 15 m/s and 20 m/s but level-2 has highest Cd except 25 m/s has largest drag coefficient up to -0.7

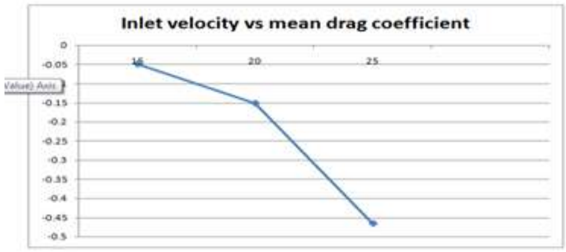

Figure7. Mean Cd distributions along chord height of the building

IV. CONCLUSIONS

In the present study, pressure measurements on a 1:2:3 rectangular building model (8 cm × 16 cm × 24 cm) have been carried out in a wind tunnel under uniform flow conditions for the three different velocities as 15 m/s, 20 m/s and 25 m/s. The measured pressures at 3 different levels (4 cm, 12 cm, and 20 cm) on the building model have been analyzed to obtain mean values of pressure coefficients and drag coefficients. This has been performed for 0° angle of wind incidence. The pressure coefficient values on the windward side are comparable at all levels except at Level-1, which may be due to the edge effect near the surface of the ground. At the leeward side the values at all levels are comparable and hence we can say that the effect is not as predominant on the leeward side as it is on the windward side.

The mean drag coefficients were increased with increasing velocities. The evaluated mean drag coefficient value of 0.05 for 15 m/s, 0.15 for 20 m/s and 0.47 for 25 m/s of 0° wind incidence is comparable to the value of 1.1 provided in IS 875 (Part 3) – 1987 for 10.31 m/s. Hence the variation in mean suction pressure coefficient values on side and leeward faces is lesser than the code values as expected. It is found that, when the study is carried out under non uniform flow condition, as practical phenomena, the values given by the present study is observed to be significantly lesser than the values given by code. When the aerodynamics of the structure and surrounding terrain is complex, code does not give accurate information‟s of wind forces using simplified code provisions. Hence wind tunnel testing is vital in such cases for evaluating wind forces accurately.

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