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Wind Pressure Distribution on Domical Roofs

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***Abstract*— Present paper describes the details of the experimental study carried out on the models of low-rise buildings with domical roofs. Wind pressure measurements are made on rigid models by placing them in an open circuit boundary layer wind tunnel. The study includes square and rectangular plan buildings with one and two domes respectively. The experimental results of pressure measurements are reported in the form of contours of mean wind pressure coefficients on the surfaces of domes. Results presented in the paper are of great use for the structural designers while designing buildings with domical roofs. The experts responsible for revising wind-loading codes from time to time can also use these values.**

***Index Terms*— Domical Roofs, Interference Effect, Low-rise Buildings, Wind Pressure Coefficients.**

I. INTRODUCTION

Although high-rise buildings are being constructed these days both for residential as well as office purposes, low-rise buildings have yet not lost their importance. These are still built for residential, industrial, institutional and assembly purposes. Air, railway and bus terminal buildings fall in this category. Exhibition halls, hangers and sport complexes are also examples of low-rise buildings. Whereas many of these are constructed with simple roof form such as flat or sloping roof, some are provided with curved roof due to functional and / or esthetic reasons.

Wind is one of the important loads to be considered while designing the roofs of low-rise buildings. The structural designers while designing building roofs refer to relevant code of practices of various countries dealing with wind loads [1]-[5]. However, available information in such codes regarding wind pressure coefficients on roofs in general and especially on curved roofs is very limited, which are only for single-span curved roof buildings. Whereas wind pressure values on a building roof get modified due to the presence of nearby building, such information is not available in code of practices. Review of the research work published during last 3 decades [6]-[12], also indicates that very limited information regarding wind pressure coefficients on curved roofs is available.

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An experimental study has, therefore, been carried out by the authors on the models of low-rise buildings with domical roofs.

II. EXPERIMENTAL PROGRAMME

A. Details of Models

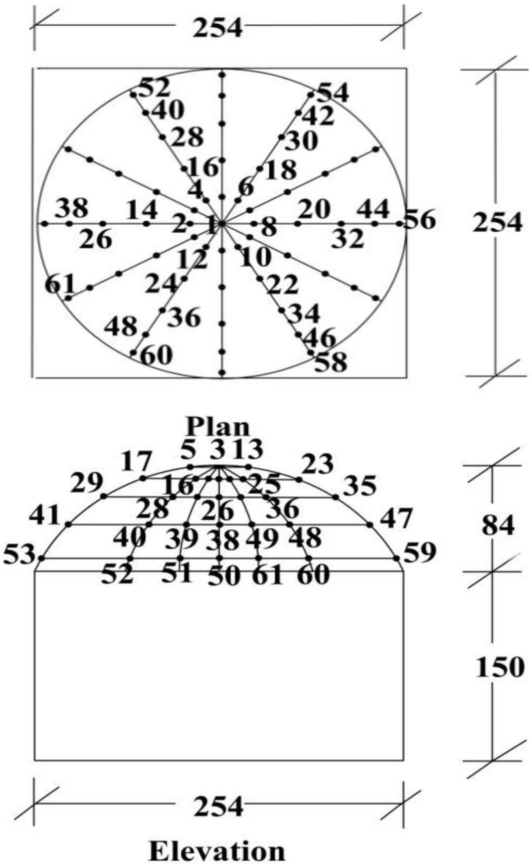
Prototypes chosen for study are low-rise buildings of (i) square plan with one dome and (ii) rectangular plan with 2 domes. Wall elements of the models of the buildings are made up of Perspex sheet and domes are made of aluminum. The model of the square plan building block has a plan dimension of 254 x 254 mm and height of 150 mm. Domes have diameter of 254 mm and height of 84 mm (Fig. 1). Two blocks of square plan shape are built. Rectangular plan building block with 2 domes is obtained by simply keeping 2 blocks of square plan side by side (Fig. 2). Dome of one of two square plan building blocks are provided with pressure points for the measurement of pressures on roof surface. Total of 61 pressure points are provided at the locations where latitudes and longitudes on the dome intersect each other. In case of rectangular plan building with 2 domes, the instrumented model is placed at two different locations for measurement of pressures first as windward dome and then as leeward dome.

B. Wind Flow Characteristics

The experiments are carried out in an Open Circuit Boundary Layer Wind Tunnel at Indian Institute of Technology Roorkee, India. The wind tunnel has a test section of 15 m length with a cross sectional dimensions of 2 m (width) x 2 m (height). Flow roughening devices such as vortex generators, barrier wall and cubical blocks of various sizes are used on the upstream end of the test section to achieve boundary layer mean wind velocity profile. Power-law index of the profile obtained is 0.166. The models are placed at the centre of the turntable and are tested under free stream wind velocity of 10 m/sec measured at 1 m height above the floor of the tunnel.

C. Measurement Technique

Model of the low-rise building with square plan having domical roof is placed at the centre of the wind tunnel in such a way that wind hits perpendicular to one of the walls and pressure point number 2, 14, 26, 38 and 50 fall in the direction of wind (Fig. 3). Pressure measurements are made by connecting pressure tubing from all 61 pressure points one by one to the pressure transducer. Values of pressures varying with time are recorded at an interval of 1 second for duration of 30 seconds at each pressure point and stored in a computer through data taker.

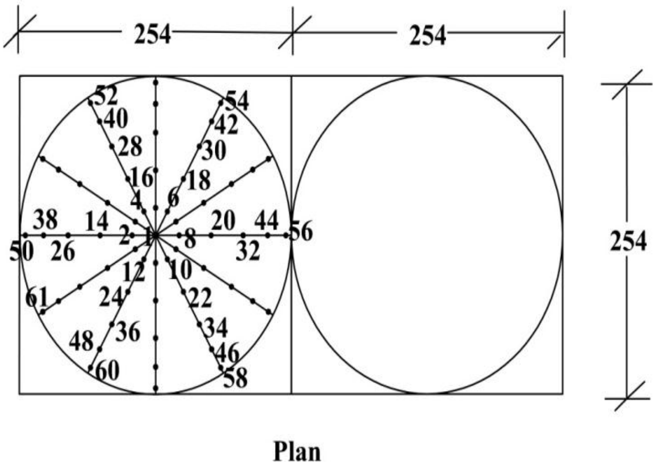


(All dimensions are in mm)

Fig.1 Dimensions of the model of square plan building with domical roof

In order to measure wind pressure distribution on the domes of rectangular plan building with 2 domes, 2 blocks of square plan building models are placed one behind another in alignment in the direction of wind (Fig. 4). Building block with instrumented dome is first placed on upstream side and pressure values are measured at all 61 pressure points. Then the instrumented model is placed on downstream side and measurements of pressure values are taken at all pressure points again. Thus pressure distribution on both windward and leeward domes are obtained.

Values of mean wind pressure coefficients (Cp) are then calculated from the records of pressures (P) at all pressure points using the relationship; $Cp = P / (0.6\ V_{ref}^{\ 2})$, where, V_{ref} is the reference wind velocity at 1 m height above the floor of the wind tunnel.



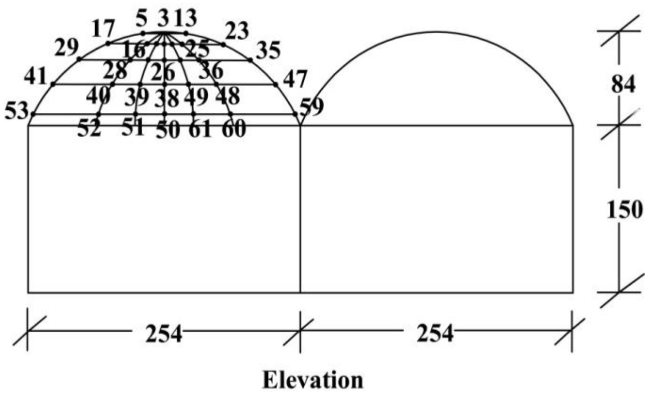


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Fig. 2 Rectangular plan building with 2 domes

Fig. 3 Model of square plan building with domical roof inside the tunnel

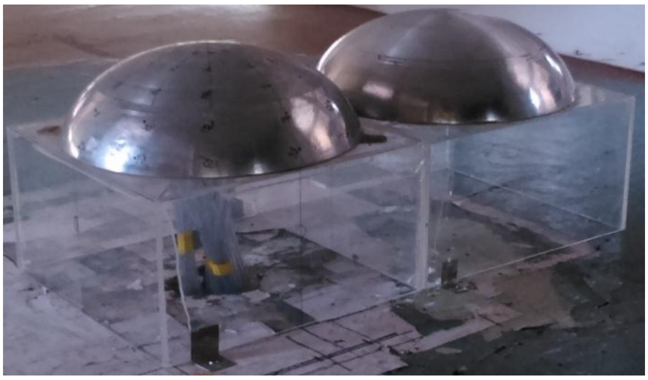

Fig. 4 Model of rectangular plan building with 2 domes inside the tunnel

III. RESULTS AND DISCUSSION

A. Square Plan Building with Single Dome

Fig. 5 represents wind pressure distribution on the dome of the square plan building model when wind hits perpendicular to one of the walls.

It is observed from the figure that except a small strip near the base of the dome on windward side, entire dome is subjected to suction. Maximum positive mean wind pressure coefficient (Cp) near the base of the dome on windward side is around 0.2. Suction increases as one moves from the base towards the peak of the dome. Maximum negative wind pressure coefficient near the peak of the dome is some where between -0.5 and -0.55, which reduces towards leeward edge. Value of mean wind pressure coefficient near the base of the dome on leeward side is some where between -0.05 and -0.1.

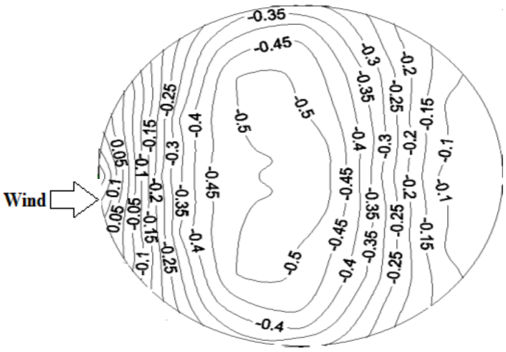

Fig. 5 Wind pressure distribution on the domical roof of square plan building

B. Rectangular Plan Building with 2 Domes

Wind pressure distribution on the domes of a rectangular plan building with 2 domes when domes are placed in the direction of wind behind one another and wind hits perpendicular to one of the short walls can be seen in Fig. 6. It is observed from the figure that the windward portion of the windward dome is subjected to similar pressure distribution as in the case of single dome building. However, leeward portion of the windward dome near the base is subjected to pressure although of small magniture. Similarly, maximum suction point is not the peak of the dome but a point towards windward side.

It is also noticed from Fig. 6 that a large portion of leeward dome on windward side near the base is subjected to pressure with value of maximum positive pressure coefficient being 0.25. Rest of the leeward dome is subjected to suction. Although the maximum value of suction is quite similar to that on windward dome, it occours slightly towards leeward side and not on the peak of the dome. Suction near the base of leeward side of leeward dome is quite similar to that in case of square plan building with single dome, in value.

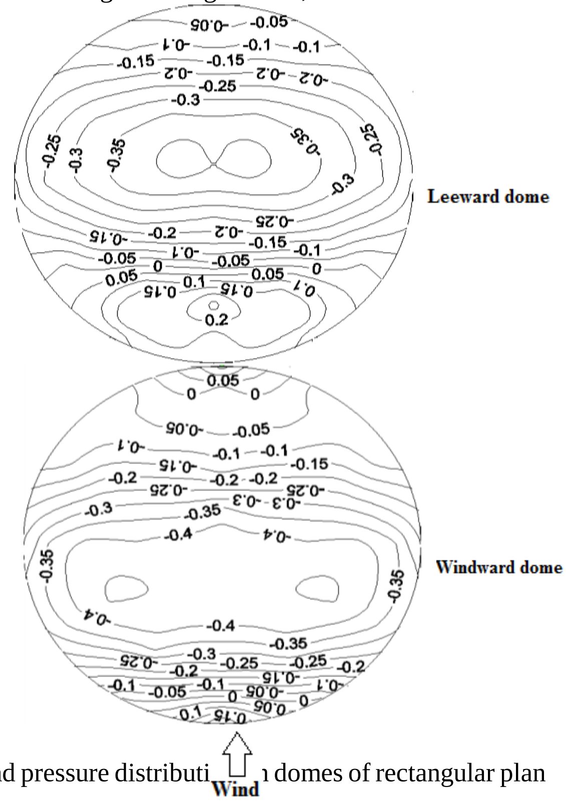

Fig.6 Wind pressure distributi[illegible]n domes of rectangular plan building

IV. CONCLUSIONS

Following conclusions are drawn from the study presented herein.

1. Wind pressure distribution on the surface of a domical roof is generally suction in nature.
2. Maximum suction occurs near the peak of the dome which reduces both towards windward side and leeward side.
3. A small strip near the base of single dome on windward side is subjected to pressure although of small magnitude.
4. In case of 2 domes in the alignment in the direction of wind, leeward portion of the windward dome near the base is subjected to pressure although of small magnitude.
5. A large portion of leeward dome on windward side near the base as compared to windward dome, is subjected to pressure.
6. Suction near the base of leeward side of leeward dome is quite similar to that in case of square plan building with single dome, in value.

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