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Investigating the Distribution of Wind Load Variation on a Building with a Gable Roof by Altering the Length of the Canopy.

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Abstract

Typically, a slab that is referred to as a canopy is installed at the entry door of the structure, which is located at ground level. This article discusses wind tunnel research that was conducted to determine the influence that the length of the canopy has on the wind loads that are placed on buildings with gable roofs. A variety of stiff models of buildings with gable roofs and varied canopy lengths have been produced. Perspex sheets are used to construct the models, and pressure points are placed on each surface of the sheet in order to measure the distribution of pressure. The wind tunnel with a closed circuit is used to test all of the models in order to investigate the impact that the length of the canopy and the angle of the wind incidence have on the distribution of wind pressure. The conclusion that can be drawn from this is that the length of the connected canopy has a significant impact on the pressure or suction coefficients that are present on the canopy surfaces.

Keywords: Low-rise buildings, Wind loads, Canopy, Pressure distribution

1. Introduction

For the purpose of ensuring the safety of the building with the canopy connected, extra care is necessary. However, there is a relatively limited amount of information accessible on wind pressure coefficients on structures that have attached canopies. This information may be found in the codes of practices of different countries that deal with wind loads. According to the Indian Standard on wind loads [1,] the wind pressure coefficient is shown for both supported and unsupported canopy respectively. There is no relationship between the length, width, or angle of the canopy and the pressure coefficients that are accessible in this code for unsupported canopy designs. The pressure coefficients for connected canopy are provided by the Australian code [2] with a level of detail that is significantly superior to that provided by the Indian Standard; nonetheless, the information that is supplied is still relatively restricted. Additionally, a few scholars, such as Paluch et al. [3], Jancaukas and Holmes [4], Goyal and Ahuja [5], Goyal et al. [6], Goyal, R., Sunn, A., Ahuja, A.K., [7],Xing F, Mohotti D, Chauhan K.[8], Garau M, Badas MG, Ferrari S, Seoni A, Querzoli G[9] and Uematsu Y, Yamamura R. [10] have shown an interest in determining the impact that connected canopies have on low-rise structures.

2. Experimental Program

2.1 Detail of Models

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There are four different configurations of a rectangular plan gable roof structure that are joined with varied lengths of canopy. The models are constructed out of sheets of Perspex that range in thickness from thin to thick. As can be seen in Figure 1, the plan dimension of the building model is maintained at 300 mm by 150 mm, and the eaves height is maintained at 150 mm. Keep the slope of the gable roof at twenty degrees. The connected canopy has a width of fifty millimetres and a length that ranges from seventy-five to three hundred millimetres. Some of the versions are referred to as HC-75 (horizontal canopy-75), HC-150, HC-225, and HC-300, and their names are determined by the length of the canopy. Table 1 provides a comprehensive breakdown of the dimensions of the models. The pressure points that are used to measure the surface pressure are strategically placed on every face of the structure and canopy. The chart also includes an indication of the number of pressure points that are located on each face.

Flow Characteristics

In the closed circuit boundary wind tunnel of the Civil Engineering Department at the Indian Institute of Technology Roorkee, India, each and every model is put through its paces for evaluation. The length of the test section is 8.25 metres, and the cross section of the wind tunnel have dimensions of 1.15 metres in width and 0.82 metres in height. The models are positioned at a distance of 5.8 metres from the edge of the test section that is located upstream. At the upstream end of the test section, a grid of hollow circular tubes is positioned in order to provide a boundary layer for the flow of the wind tunnel [7].

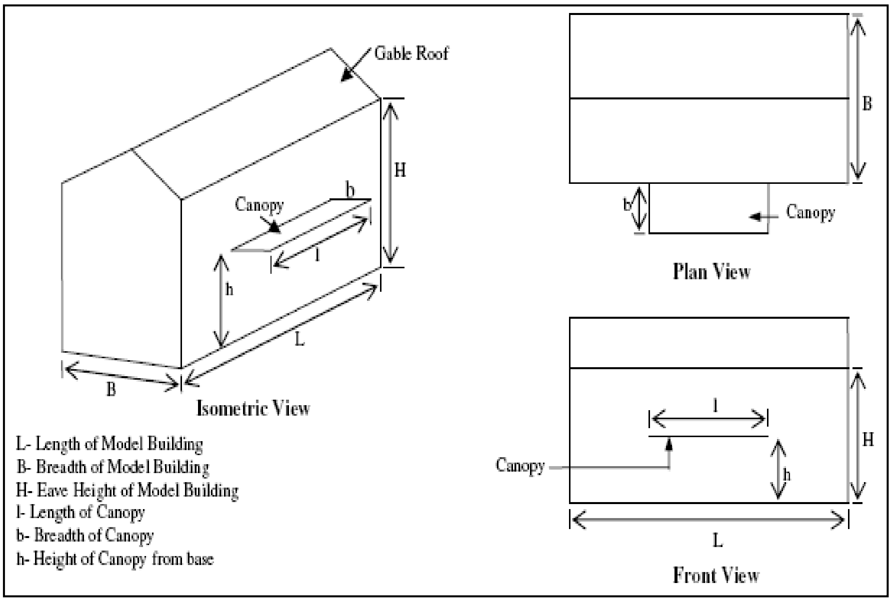

Figure 1 Model Detail of Gable Roof Building with Attached Canopy

Table 1 Detail of Model Dimension and Pressure Points

Model	Dimensions (mm)			Aspect Ratios			Pressure Points on Faces					
	L	*B*	*H*	*l/L*	*h/H*	*b/l*	*A*	*B&C*	*D*	*E&F*	*G Upper*	*G Lower*
HC-75	300	150	150	1/4	1/2	2/3	66	44	66	47	15	15
HC-150				1/2	1/2	1/3	32	28	35	28	30	30
HC-225				3/4	1/2	2/9	30	28	35	28	45	45
HC-300				1	1/2	1/6	28	28	35	28	60	60

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3. Results And Discussion

As was indicated earlier, the purpose of this research is to investigate the impact that the length of the connected canopy has on the distribution of wind pressure on the gable roof building as well as the canopy itself. In the wind tunnel, each of the four models, HC-75, HC-150, HC-225, and HC-300, is tested individually for a total of thirteen wind incidence angles ranging from 0 degrees to 180 degrees at intervals of 15 degrees. The results of these tests are shown in Figure 2. For the purpose of determining the pressure coefficients, a Baratron Pressure Gauge is used to measure the wind pressure that is exerted on the walls, roof, and canopy. Following the determination of the pressures, the pressure coefficients are computed by using the particular equation that is applicable.

Table 2 gives a tabular representation of the values of the face average coefficients for the top surfaces of the canopy. The value of the pressure coefficient for a wind angle of 0 degrees remains the same for 150 millimetres in length when compared to 75 millimetres in length. For 225 millimetres in length, the value decreases, and for 300 millimetres in length, the value decreases even more. It is not the case that this pattern of change in Cp is consistent across all available wind directions. When the wind angle is 45 degrees, the value of the pressure coefficients first rises with the length of the canopy, then the value falls, and finally the value reduces even more with the length of the canopy. At a wind speed of 90 degrees, the value of Cp is -0.69 for a canopy that is 75 millimetres long, it rises to -0.74 for a canopy that is 150 millimetres long, it falls to -0.65 for a canopy that is 25 millimetres long, and lastly it rises slightly to -0.66 for a canopy that is 300 millimetres long. When the wind angle is 135 degrees, the distribution is essentially identical to that of a wind angle of 90 degrees. The fluctuation in pressure coefficients in response to an increase in the length of the canopy is relatively minimal when the wind angle is 180 degrees. In general, the canopy with a length of 150 millimetres experiences the highest possible value of pressure coefficient, while the canopy with a length of 225 millimetres experiences the lowest possible values of pressure coefficient. The data shown in this table makes it abundantly evident that the pressure coefficient shifts from being negative to being positive when the wind incidence angle increases from 0 degrees (which is parallel to the ridge) to 90 degrees (which is perpendicular to the ridge). When the angle of wind incidence is between 0 and 30 degrees, the pressure coefficient is negative, but when the angle is any other angle, it is positive.

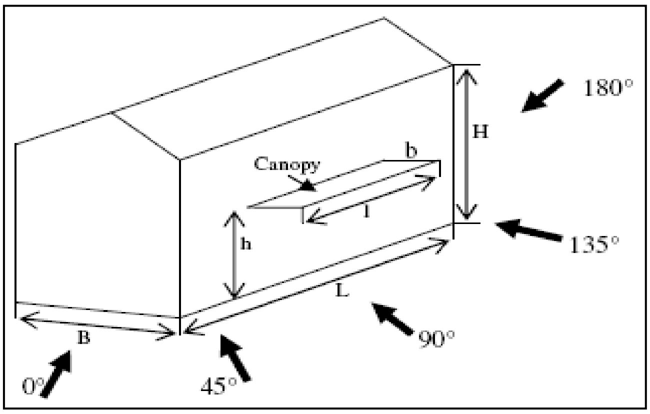

Figure 2 Angle of attack of wind on model

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Table 2 Face average pressure coefficients on canopy upper surfaces

Wind Angle (°)	Model			
	HC75	HC150	HC225	HC300
0	0.75	0.75	0.69	0.67
15	0.75	0.71	0.62	0.57
30	0.64	0.57	0.52	0.47
45	0.23	0.35	0.31	0.27
60	-0.10	-0.15	0.03	0.04
75	-0.17	-0.34	-0.34	-0.62
90	-0.69	-0.74	-0.65	-0.66
105	-0.89	-0.93	-0.91	-0.76
120	-0.90	-0.93	-0.97	-0.85
135	-0.94	-0.95	-0.88	-0.92
150	-0.81	-0.85	-0.86	-0.8
165	-0.70	-0.71	-0.71	-0.67
180	-0.62	-0.65	-0.64	-0.63

Table 3 contains the values of the face average pressure coefficient that are represented on the lower surfaces of the canopy. The pressure coefficient for a wind speed of 0 degrees first rises as the length of the canopy grows, namely by 150 millimetres; after that, it falls for 225 millimetres, and then stays the same for 300 millimetres beyond that. At a 45-degree wind angle, the Cp value is 0.19 for a canopy length of 75 millimetres, it rises to 0.32 for a canopy length of 150 millimetres, then it falls to 0.30 for a canopy length of 225 millimetres, and it falls once more to 0.25 for a canopy length of 300 millimetres. When the wind angle is 90 degrees, the pattern of pressure distribution is the same as when the wind angle is 45 degrees. When the wind angle is 135 degrees and 180 degrees, the suction coefficient values first grow, then fall, and then increase once again with each successive wind angle. In relation to the change in the length of the canopy, the difference in coefficient values is very little when the wind angle is 180 degrees as well.

Table 3 Face average pressure coefficients on canopy lower surfaces

Wind Angle (°)	Model			
	LC75	LC150	LC225	LC300
0	0.55	0.58	0.48	0.48
15	0.43	0.50	0.46	0.42
30	0.45	0.45	0.41	0.37
45	0.19	0.32	0.30	0.25
60	-0.08	-0.16	0.03	0.02
75	-0.11	-0.32	-0.34	-0.68
90	-0.62	-0.67	-0.58	-0.65
105	-0.79	-0.82	-0.74	-0.64
120	-0.71	-0.74	-0.76	-0.65
135	-0.72	-0.76	-0.7	-0.72
150	-0.72	-0.75	-0.76	-0.67
165	-0.61	-0.63	-0.62	-0.56
180	-0.54	-0.57	-0.56	-0.53

When each incidence angle is considered, the highest and lowest possible values of Cp are determined. Figure 3 is an example of a common X-Y plot that depicts the Cpmax, Cpmean, and

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Cpmin values. With the help of these plots, it is possible to see that the value of pressure coefficients is much lower on the lower surface in comparison to the higher surface. In addition, the largest peak negative pressure arises between 0 degrees and 15 degrees of wind aggression.

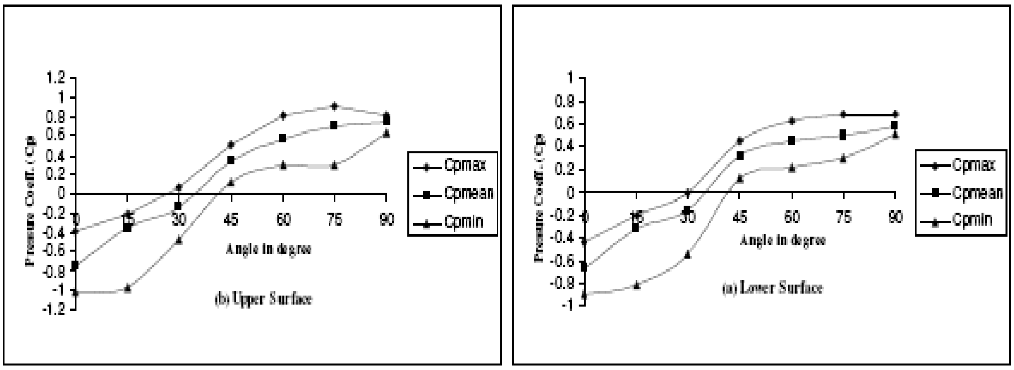
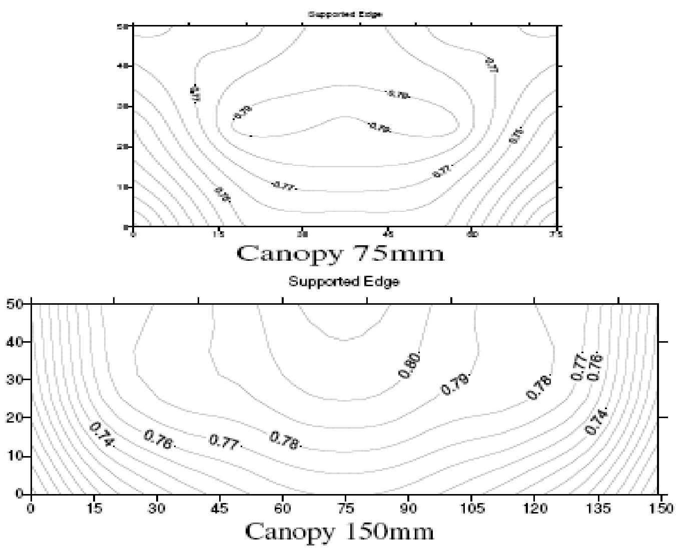


Figure 3 Plots of pressure coefficients on canopy of model HC-150

Additionally, the contours of pressure coefficients are shown for each wind incidence angle for each face of the building model and canopy. This is done for each face of the structure. After plotting the contours, the region of pressure concentration on the specific face of the model is determined by determining the contours. The pressure distribution is symmetrical to the surface when the wind angle is between 0 and 180 degrees, but it forms patterns that are similarly distributed throughout the whole canopy. There is a tiny concentration of pressure on the left edge of the surface at wind angles of 45 degrees and 135 degrees, indicating that the pressure distribution on the surface is uneven. The pressure distribution was broad and parallel to the short edges of the canopies when the wind angle was determined to be 90 degrees. Figure 4 illustrates the contours of the pressure coefficient located on the top surface of the canopy for all of the models when the wind angle is 0 degrees. It is evident that the pressure distribution on the surface of the canopy is directly proportional to the plane over all of the lengths of the canopy. Those corners of the edge that is not supported are where the pressure is concentrated. There is a vast distribution of pressure in the middle area, whereas there is a restricted distribution of pressure towards the extremities of the surface.



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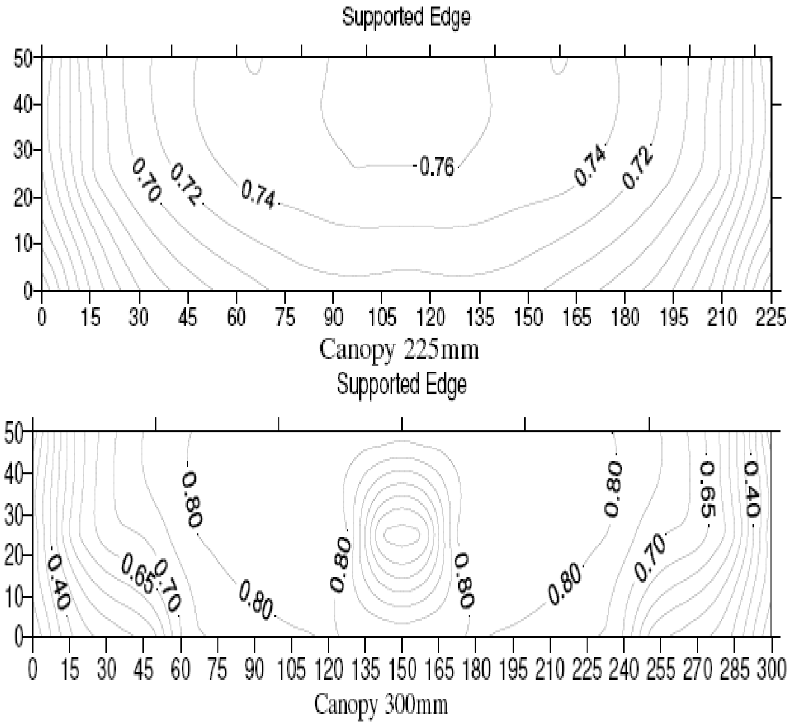

Figure 4 Pressure coefficient contours on upper surface of canopy of all the models for 0° wind angle

4. Conclusion

The following conclusions are formed from the current research based on the analysis and the data that were obtained.

- As the wind angle changes from 0 degrees to 90 degrees, the pressure coefficient shifts from being negative to being positive.
- When the wind angle is between 30 and 45 degrees, the sign of the pressure begins to shift from negative to positive.
- This indicates that there is no pressure exerted on the canopy, even when the wind angle is 35 degrees.
- Around a wind angle of 15 degrees, the peak suction exerts its influence on the top surface of the canopy.
- The pressure or suction exerted on the lower surface of the canopy is always lower than on the top surface.
- When the wind angle is 90 degrees, the pressures on the canopy are concentrated along the edges, and when the wind angle is 0 degrees, the pressures decrease.
- As the length of the canopy increases, the pressure and suction exerted on it also increases.

5. References

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