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VARIATION OF WIND LOAD DISTRIBUTION ON GABLE ROOF BUILDING WITH VARYING LENGTH OF ATTACHED CANOPY

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ABSTRACT

Generally a slab called canopy is provided at the entrance door of building at ground level. Present paper deals with wind tunnel study carried out for finding the effect of length of canopy on wind loads on gable roof buildings. The rigid models of gable roof buildings with varying canopy length have been prepared. The models are made of Perspex sheet having pressure points on all the surfaces to measure pressure distribution. All the models are tested in the closed circuit wind tunnel to study the influence of canopy length and wind incidence angle on wind pressure distribution. It is concluded that the pressure or suction coefficients on the canopy surfaces are widely influences by the length of the attached canopy.

Key words: Low-rise buildings, Wind loads, Canopies, Pressure distribution

INTRODUCTION

A special attention is required for safe design of building with attached canopy. Information regarding the wind pressure coefficients on buildings with attached canopies is available in codes of practices of various countries dealing with wind loads, however such information is very limited. Indian Standard on wind loads [1] gives the wind pressure coefficient for supported and unsupported canopy. The pressure coefficients available in this code for unsupported canopy are irrespective of length, breadth and angle of canopy. Australian code [2] gives the pressure coefficients for attached canopy with quite good detail compared to Indian Standard, but still the information available is very limited. Also a few researchers like Paluch et.al. [3], Jancaukas and Holmes [4], Goyal and Ahuja [5] and Goyal et.al. [6] have shown their interest in finding the influence of attached canopies on low rise buildings.

EXPERIMENTAL PROGRAM

Detail of Models

Four models of rectangular plan gable roof building attached with varying length of canopy are made. The Perspex sheet of varying thickness is used for making the models. The plan size of building model is kept as 300x150 mm and eaves height is kept as 150 mm (Fig.1). The gable roof slope is kept as 20°. The width of attached canopy is 50 mm and length varies between 75 to 300 mm. Depending upon the length of canopy the models are named as HC-75 (horizontal canopy-75), HC-150, HC-225 and HC-300. Detailed dimensions of the models are given in Table 1. Each face of building and canopy is having the pressure points for measuring the surface pressure. The number of pressure points on each face is also indicated in the table.

Flow Characteristics

All the models are tested in the closed circuit boundary wind tunnel of Civil Engineering Department, Indian Institute of Technology Roorkee, India. The cross section of wind tunnel is 1.15 m (width) x 0.82 m (height) and length of the test section is 8.25 m. Models are placed at a distance of 5.8 m from the upstream edge of the test section. The flow of the wind tunnel is made boundary layer by placing a grid of hollow circular tubes at the upstream end of the test section [7].

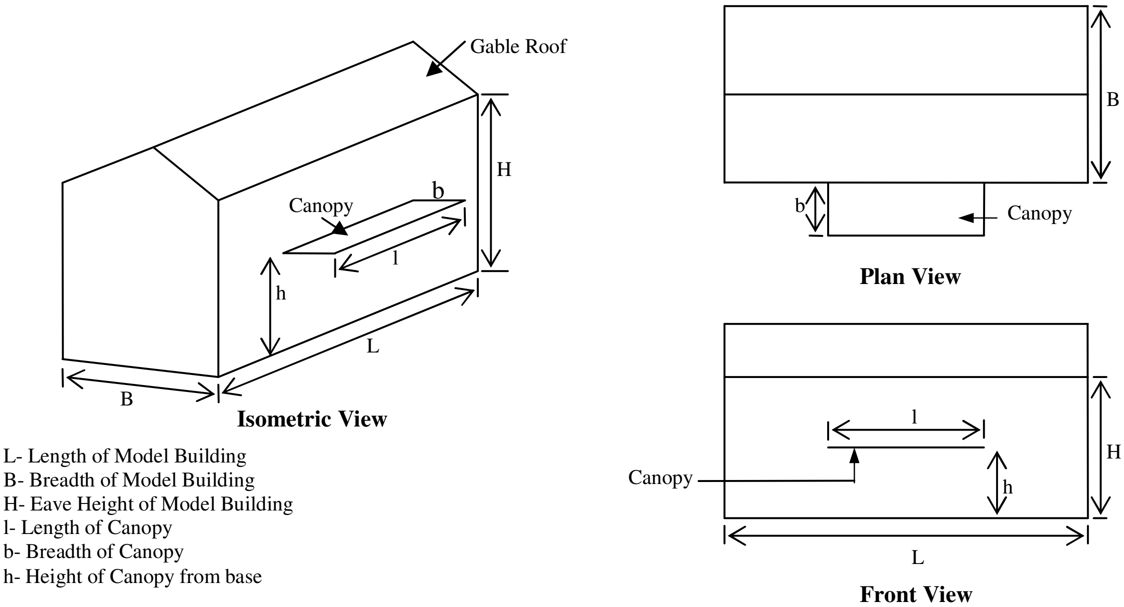


Figure 1 Model detail of gable roof building with attached canopy

Table 1 Details 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

RESULTS AND DISCUSSION

As mentioned earlier, the present study is to evaluate the influence of length of the attached canopy on the wind pressure distribution on gable roof building and canopy itself. All four models namely HC-75, HC-150, HC-225 and HC-300 are tested one by one in the wind tunnel for 13 wind incidence angles from 0° to 180° at an interval of 15° (Fig. 2). The wind pressure on the walls, roof and canopy is measured through Baratron Pressure Gauge for finding the pressure coefficients. After finding the pressures, the pressure coefficients are calculated by using the appropriate equation.

The values of face average coefficients for canopy upper surfaces are tabulated in Table 2. The pressure coefficient value for 0° wind angle first remain unchanged for 150mm length as compare to 75mm length, then the value reduces for 225mm length and further reduces for 300mm length. This pattern of variation of Cp is not uniform for all the wind directions. For 45° wind angle the value of pressure coefficients first increases with the increase in length of canopy, then the value decreases and further decreases with the increase of length of canopy. At 90° wind the value of Cp is -0.69 for 75mm long canopy, it increases to -0.74 for 150mm long canopy, then it decreases to -0.65 for 225mm length and finally it increases a bit to -0.66 for 300mm long canopy. At 135° wind angle the distribution is almost similar as that of wind angle 90°. At wind angle 180° the variation in pressure coefficients is very small with the increase in length of canopy. In general the canopy of 150mm length experiences the maximum value of pressure coefficient and canopy length 225mm length experiences the minimum values of pressure coefficients. From this table it is clear that with the increase of wind incidence angle from 0° (parallel to ridge) to 90° (perpendicular to ridge), the pressure coefficient changes from negative to positive. For wind incidence angle of 0° to 30°, pressure coefficient is negative and for rest of angles it is positive.

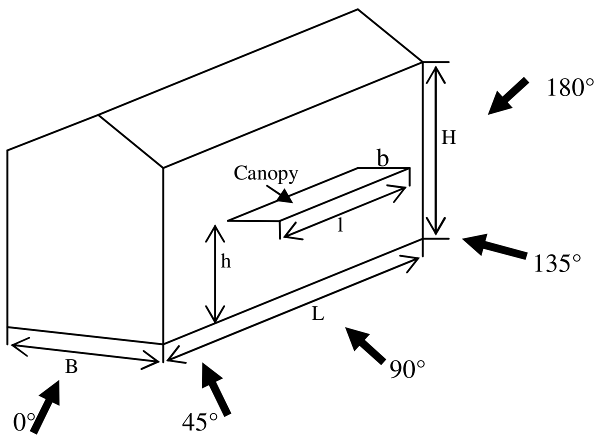


Figure 2 Angle of attack of wind on model

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

The face average pressure coefficient values on canopy lower surfaces are presented in Table 3. The pressure coefficient for 0° wind first increases with the increase in canopy length i.e. 150mm, then it decrease for 225mm length and remain unchanged for 300mm length. For 45° wind angle Cp is 0.19 for 75mm canopy length, it increases to 0.32 for 150mm long canopy, then it decreases to 0.30 for 225 mm canopy and again decreases to 0.25 for 300mm long canopy. For 90° wind angle also the pressure distribution pattern is same as that of 45° wind. For 135° wind angle and 180° wind angle the suction coefficient values first increases then decrease and again increases. The variation in coefficient values is very small with respect to change in length of canopy for wind angle 180°.

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

The maximum and minimum value of Cp is picked up for each incidence angle. A typical X-Y plot of Cp_{max}, Cp_{mean} and Cp_{min} is drawn in Fig. 3. From these plots it can be seen that the value of pressure coefficients is comparatively less on lower surface than upper surface. Also the maximum peak negative pressure occurs between 0° and 15° wind attack

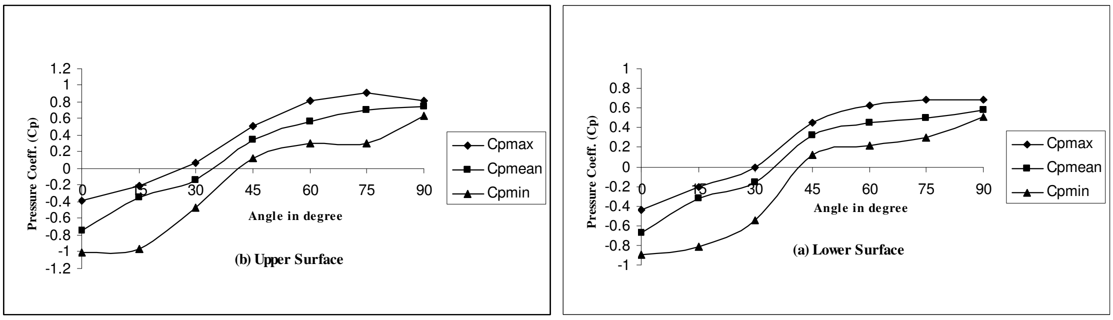
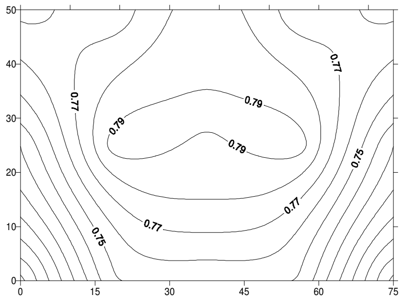
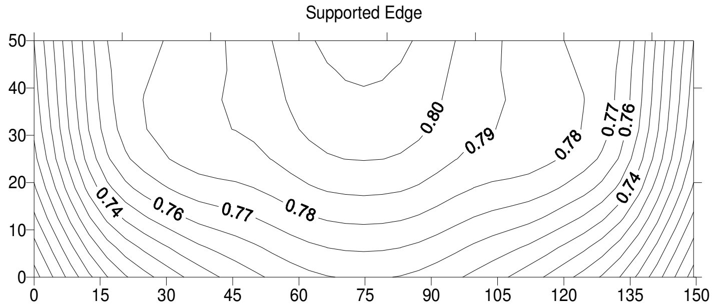


Figure 3 Plots of pressure coefficients on canopy of model HC-150

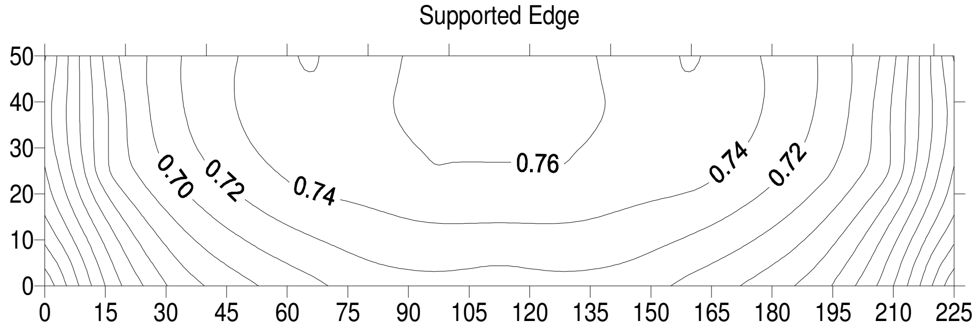
Further, for the each face of building model and canopy, the contours of pressure coefficients are plotted for each wind incidence angle. The contours are plotted to find the area of pressure concentration on the particular face of the model. At wind angle 0° and 180° the pressure distribution is symmetrical to the surface, but forming the similar patterns on all the canopy. At wind angle 45° and 135° the pressure distribution is uneven on the surface with small concentration on left edge at wind angle 45°. At 90° wind angle the pressure distribution was wide and parallel to the short edges of canopies. The pressure coefficient contours on upper surface of canopy of all the models for 0° wind angle are presented in Fig. 4. It is clear that pressure distribution on canopy surface is symmetrical to the plane on all the canopy lengths. The pressure concentrates at the corners of not supported edge. The pressure is widely distributed at the central region and closely distributed towards the ends of the surface.



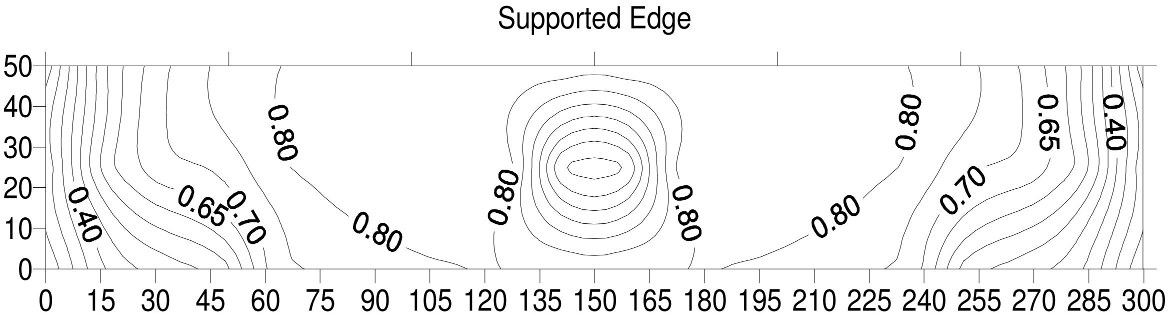
Canopy 75mm



Canopy 150mm



Canopy 225mm



Canopy 300mm

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

CONCLUSIONS

The following conclusions are drawn from the present study.

(i) The pressure coefficient changes from negative to positive as the wind angle changes from 0° towards 90°.

(ii) The pressure sign changes from negative to positive between 30° and 45° wind angle. It means there is no resultant pressure on canopy around wind angle of 35°.

(iii) The peak suction acts on upper surface of canopy around wind angle of 15°.

(iv) The pressure or suction on lower surface of canopy is always less than the upper surface of canopy.

(v) The pressures on canopy concentrate near the edges for wind angle of 90° and it reduces for wind angle of 0°.

(vi) Pressure and suction on canopy increase with the length of canopy.

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