ISSN 0974-5904, Volume 10, No. 02

DOI:10.21276/ijee.2017.10.0242

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International Journal of Earth Sciences and Engineering

April 2017, P.P. 412-417

Wind Pressure Distribution on Sky Light Roof

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Abstract: *Industrial buildings are generally provided with sloping roofs with the provision of the entry of natural light through it. Sky light roof is one of such roofs. The information available in the literature regarding wind pressure distribution on sky light roof is limited. An effort has, therefore, been made to carry out an experimental study on the model of low-rise building with Sky light roof in order to generate more information about wind pressure distribution on it. Inflexible model of the rectangular plan low-rise building is made of Perspex sheet. It is provided with many pressure points on the upper surface of the roof. The model is tested in an open circuit boundary layer wind tunnel to measure values of wind pressures at all pressure points. Wind is made to hit the model at seven wind frequency edges from 0° to 90° at an interim of 15°. Values of mean wind pressure coefficients are evaluated from the measured values of wind pressures and contours are plotted. Values of mean wind pressure coefficients obtained experimentally are also compared with those available in the literature.*

Keywords: *Wind pressure coefficient, Sky light roof, Low-rise building, Wind incidence angle*

1. Introduction

The wind loads are applied on any structures starting from low rise buildings to high rise buildings within different categories of roof and building types. Within low rise buildings, different shapes of sky light roofs exist. The research in the area of wind pressure distribution on low rise buildings have been done further by different scholars/researchers with respect to shape, size and height of building by considering different shape of the building roof. During their investigations, they observed varying pressure distribution on those buildings. Finally they determined the internal and external pressures which may be applied on those buildings. The main point of this study is to measure experimentally wind pressure distribution on upper surface of the low-rise buildings with sky light roof. Effect of roof slope and wind incidence angles on wind pressure coefficients are studied.

This paper identifies details of the experimental study carried out on the model of low-rise building with Sky light roof in order to generate more information about wind pressure distribution on it. Structural designers generally refer to code standards on wind loads of different countries [1, 2, 3, 4] to choose suitable values of wind pressure coefficients acting on sloping roofs. However, the values of wind pressure coefficients accessible in literature even for sky light roof are not sufficient. Although many researches [5, 6, 7, 8, 9, 10] have carried out model tests in wind tunnels on the models of low-rise buildings, detailed information about wind pressure distribution on gable roof with respect to varying wind incidence angle is yet not available. Therefore, an attempt has been made in the present study to obtain the information about the influence of the wind direction on wind pressure distribution.

2. Experimental Program

2.1. Wind Tunnel

Model of the building with the sky light roof is tested in open circuit wind tunnel at IIT in the Roorkee Department of Civil Engineering with cross sectional dimension of 2m*2m and test section length of 15m. Figures 1 and 2 show the velocity and turbulence intensity profile respectively measured at the downstream and of the test segment inside the wind tunnel.

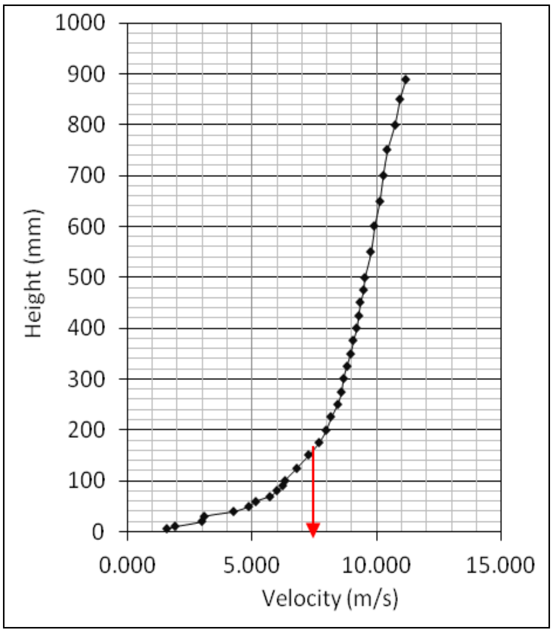

Fig. 1 *Velocity profile measured at the test section inside the wind tunnel*

Received: December 03, 2016; Accepted: February 13, 2017; Published: April 26, 2017
International Journal of Earth Sciences and Engineering, 10(02), 412-417, 2017, DOI:10.21276/ijee.2017.10.0242

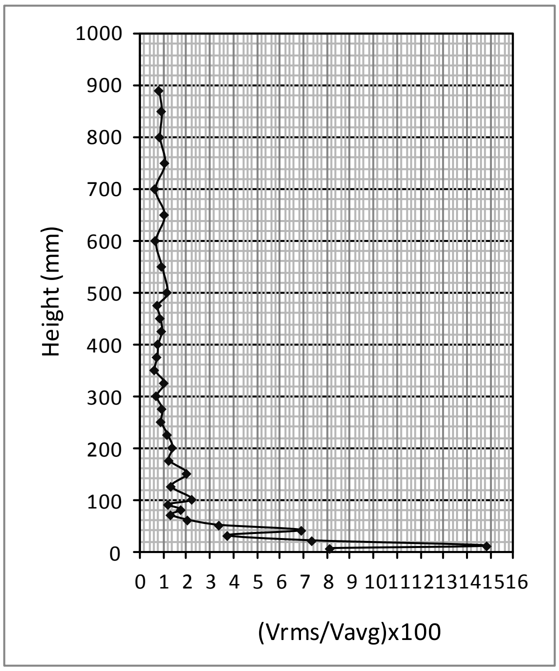

Fig. 2 Turbulence intensity profile obtained in the wind tunnel

2.2. Model Details

Prototype industrial building chosen has plan dimensions of 10 m*16 m, eaves height of 6 m and total height of 7.89 m. It has roof slope of $\alpha_1=10^0$ and $\alpha_2=50^0$. Model of the building is made of Perspex sheet at a scale of 1:40. Thus the dimension of the model are the length = 450 mm, width = 300 mm, eaves height = 100 mm and total height = 164 mm (Fig. 3). The model is provided with pressure points on external roof surface, 24 on Face –A and Face-D and 16 on Face –B and Face-C respectively (Fig. 4).

2.3. Measurement Technique

Model is placed at the center of the turn-table in such a way that wind hits the model perpendicular to long wall, i.e. at 0^0 wind incidence angles (Fig. 4 and Photo. 1). Sixty values of pressure are recorded at each pressure point at a rate of one per second.

Then average value of pressure is taken and value of wind pressure coefficient is calculated from this value of pressure. Then the turn-table is rotated by 15^0 and measurement of wind pressure is repeated till 90^0 wind incidence angle at every 15^0 interval.

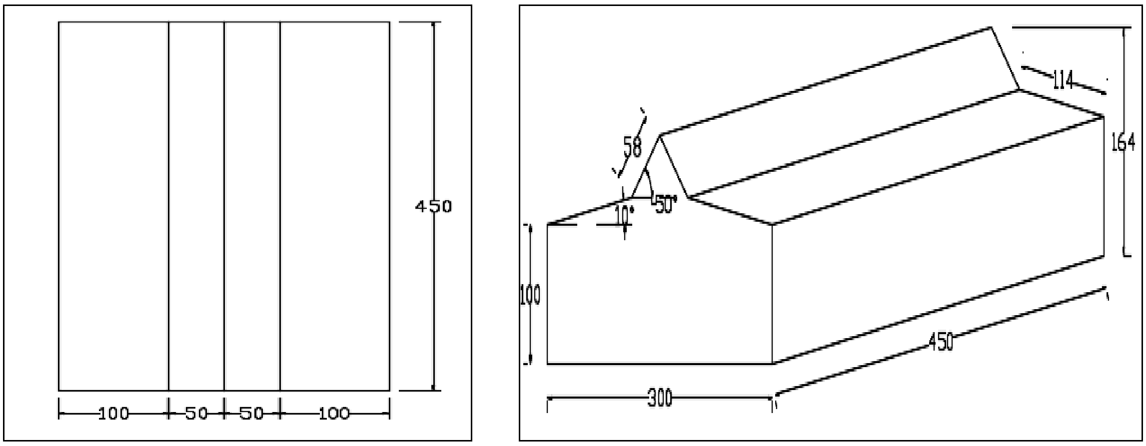

Fig. 3 *Sky light roofs model plan and isometric views and dimension of the model in mm*

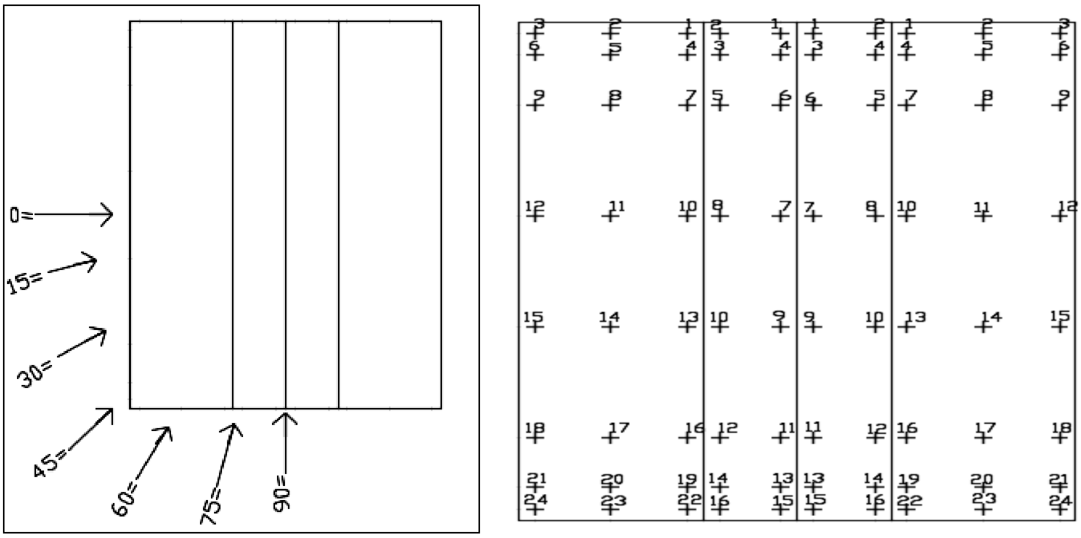

Fig. 4 *Wind directions and pressure points on the roof surface*

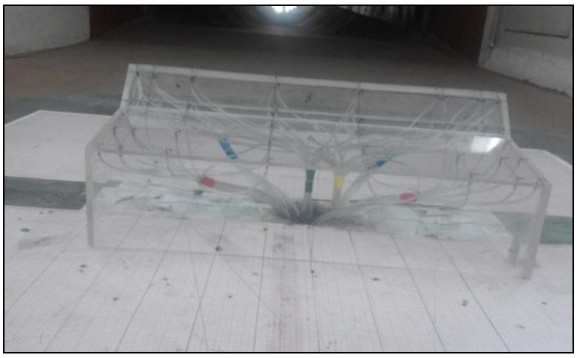

Photo 1: *Sky light model tested in wind tunnel*

3. Results and Discussion

Here the discussion and outcomes of experimental investigation of wind pressure distribution on the roof surface of the building model of rectangular sky light roof industrial building is presented and discussed.

3.1. Pressure Counters

The values of men wind pressure coefficients obtained on Face-A, Face-B, Face-C and Face-C of the model under seven wind incidence angles are shown and the pressure distribution on the surface of model is plotted in Figs. 5 to 8. It is seen that from Fig. 5 that major portion of Face-A and Face-B is exposed to pressure at 0^0 wind incidence angle. Face-C and Face-D is subjected to suction with value of suction increasing from ridge to eaves. At 15^0 wind angle, windward corner is subjected to pressure whereas leeward corner is exposed to suction at this wind direction also. It is also indicated that pressure on Face-A and Face-B decreases with increase in wind incidence angle. At 90^0 angle (Fig.6), both Face-A and Face-D and also Face- B and Face- C are subjected to suction of identical values. Value of suction near the windward edge is more as compared to leeward edge.

3.1.1 Effect of Slope of Roof

Wind flow patterns are changed with the change in slope of roof. When α_1 is changed from $\alpha_1=10^0$ to $\alpha_2=50^0$ the wind patterns are changed. Due to the slope change on the windward face of the models the pressure is uniformly distributed on the surface and also on the leeward as seen on Fig. 5. The effect of slope of roof on the wind pressure conveyance on the roof surface is clearly seen in cross sectional variation as Fig.9 and 10.

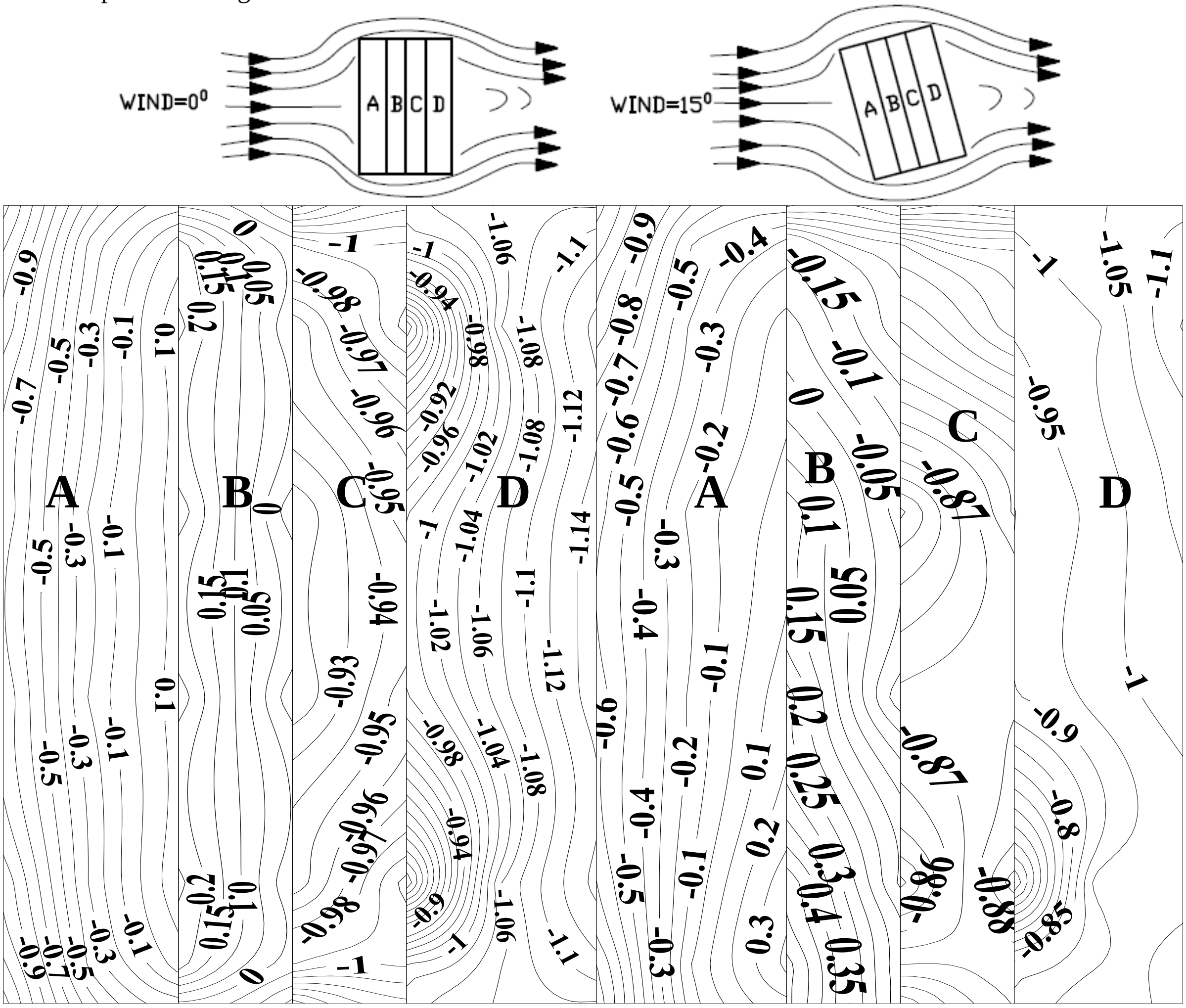

Fig. 5 *Mean wind pressure on the surface of the roofs for 0^0 & 15^0 angle of wind incidence*

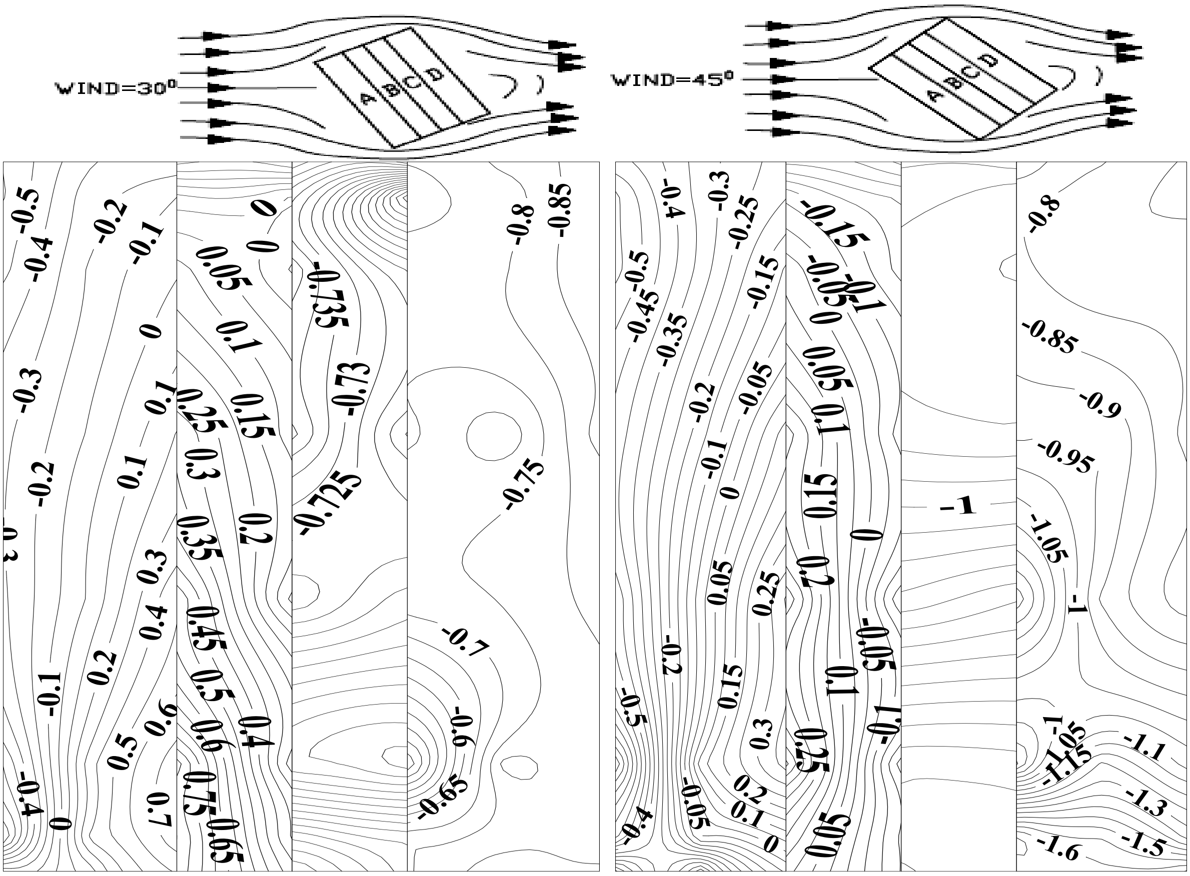

***Fig. 6** Mean wind pressure on the surface of the roofs for 30^0 & 45^0 angle of wind incidence*

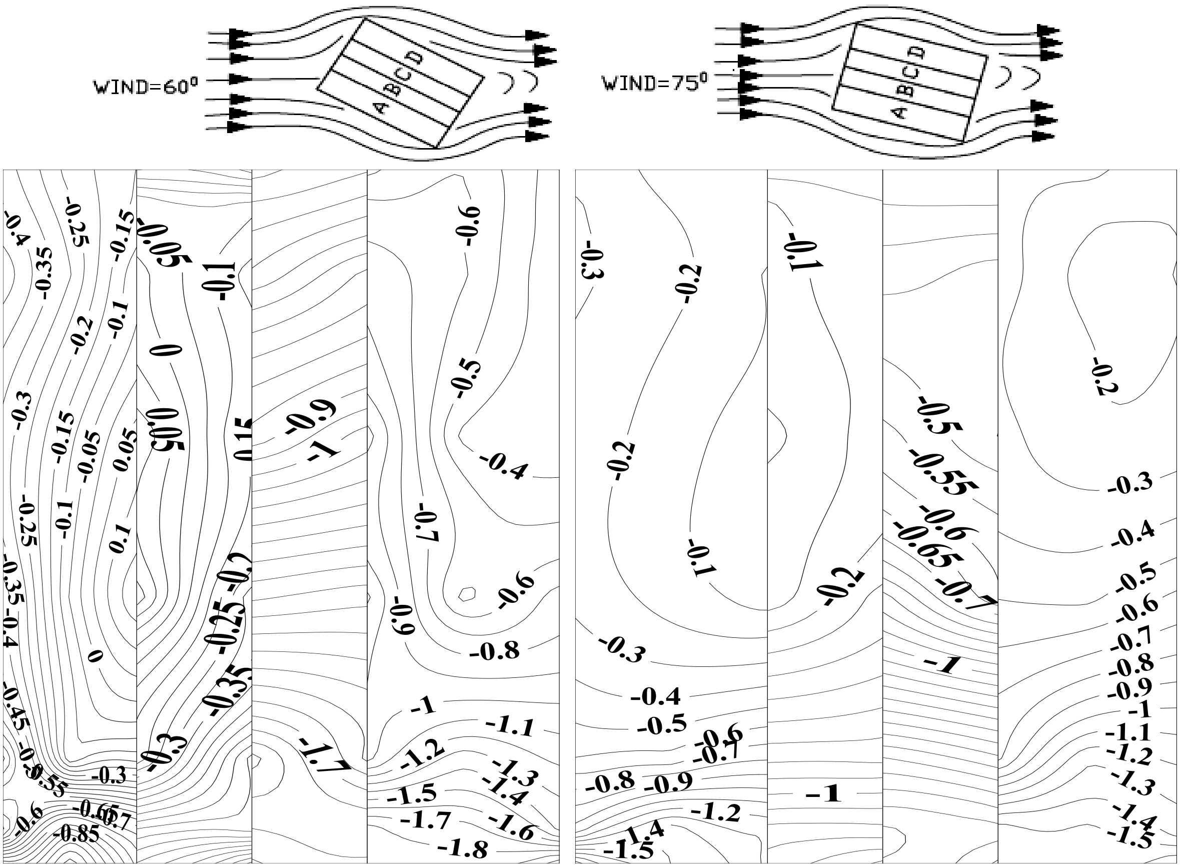

***Fig. 7** Mean wind pressure on the surface of the roofs for 60^0 & 75^0 angle of wind incidence*

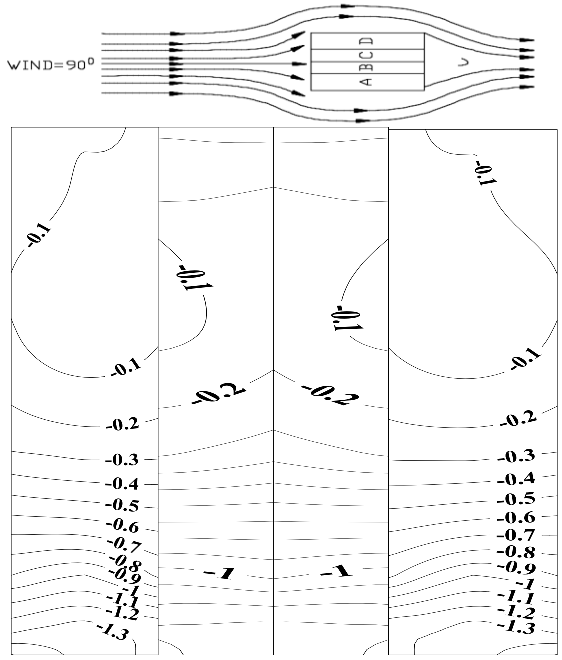

Fig. 8 *Mean wind pressure at 90˚ angle of wind incidence*

3.1.2 Cross sectional Variation

The wind pressure distribution on the sky light roof surface fluctuates when the wind hit the model at various wind incidence positions and the pressure distribution is indistinguishable as for the counters at each segment of it. Figure 9 and 10 below shows the cross sectional variation on the model when the wind hits at 0^0 and 90^0 wind angle incidence.

3.2 Maximum and Minimum Values

Table 1 show the maximum and minimum values of pressure coefficients which are observed on the roof surface. Average values obtained in the experimental study are also compared with the similar values given in I.S. code for the use of the designers in Table 2. Although no mention is found in the code, it is expected that codal values are average values over the entire roof surface.

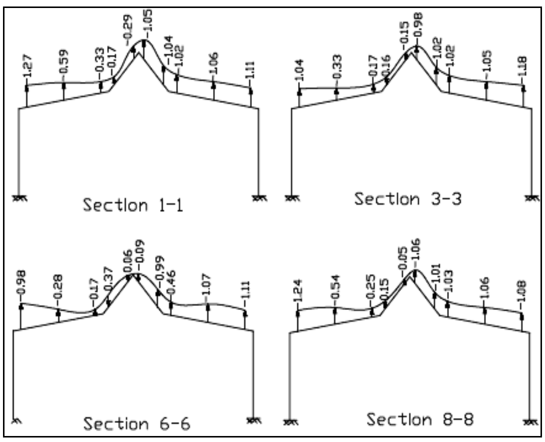

Fig. 9 *Cross-sectional variation of 0^0 wind incidence angle*

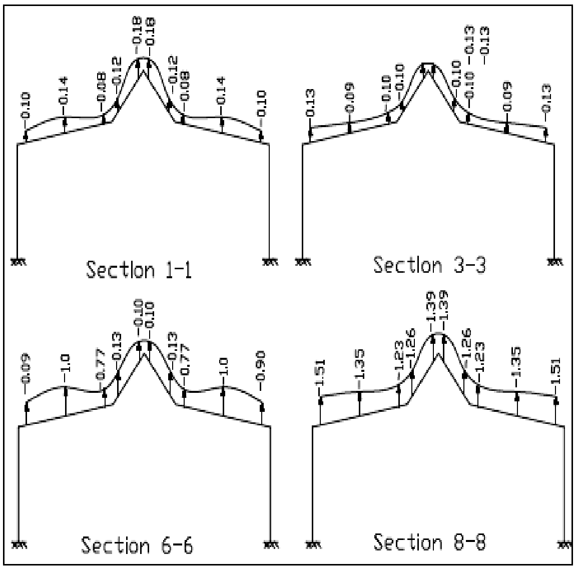

Fig. 10 *Cross-sectional variation of 90^0 wind incidence angle*

S.No.	Roof Angle	Wind incident Angle	Faces	Max. C_p values	Min. C_p Values
1	$\alpha=10^0$ and $\alpha=50^0$	0˚	**A**	0.22	-1.27
			B	0.37	-0.29
			C	-0.88	-1.06
			D	-0.46	-1.18
2		15˚	**A**	0.42	-1.25
			B	0.58	-0.51
			C	-0.88	-1.03
			D	-0.40	-1.12
3		30˚	**A**	0.76	-0.91
			B	0.88	-0.30
			C	-0.67	-0.77
			D	-0.25	-0.90
4		45˚	**A**	0.37	-0.57
			B	0.47	-0.41
			C	-0.80	-1.64
			D	-0.74	-1.66
5		60˚	**A**	-0.11	-1.18
			B	0.19	-1.07
			C	-0.38	-1.87
			D	-0.33	-2.08
6		75˚	**A**	-0.05	-1.85
			B	0.03	-1.52
			C	-0.31	-1.66
			D	-0.20	-1.68
7		90˚	**A**	-0.06	-1.52
			B	-0.02	-1.39
			C	-0.05	-1.35
			D	0.04	-1.49

Table 2: *Average pressure coefficient Cp, values for different degree of wind incidence with sky light roof*

S.No.	Roof Angle	Wind incident Angle	C_p Value				IS code Values			
			Face -A	Face-B	Face- C	Face- D	Face -A	Face-B	Face-C	Face- D
1	$\alpha=10^0$ and $\alpha=50^0$	0˚	-0.45	0.05	-0.99	-1.04	-0.6	0.4	-0.6	-0.5
2		15˚	-0.37	0.04	-0.91	-0.96				
3		30˚	-0.06	0.25	-0.73	-0.77				
4		45˚	-0.22	-0.06	-1.18	-1.06				
5		60˚	-0.38	-0.32	-1.13	-0.96				
6		75˚	-0.55	-0.53	-0.87	-0.72				
7		90˚	-0.56	-0.56	-0.55	-0.50				

Note*: For other wind incidence angle the code [IS: 875-Part 3, (2015)] did not recommend the Cp value on the roof surface*

3. Conclusions

The main observation is that high suction is developed at the edge and corner regions of the lower sloping roofs and decreases with the increase in sloping angle. Therefore, results presented in this paper regarding wind pressure distribution on sky light roof industrial building can be used by the designers with confidence for design of roof cladding as well as its supporting systems.

Acknowledgement

The work presented in this paper is part of the research work being done by the first author for his M.Tech. degree under the supervision of the second author.

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