International Journal of Engineering and Applied Sciences (IJEAS)
ISSN: 2394-3661, Volume-2, Issue-4, April 2015

Wind Pressure Distribution on Trough Canopy Roofs

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***Abstract*— Wind tunnel experiments are carried out to obtain the wind pressure distribution on trough canopy roof. The model made of Perspex sheet at a scale of 1:100 is tested in open circuit wind tunnel under boundary layer flow. Effects of wind incidence angle are studied y changing wind angle. Values of wind pressure coefficients are calculated from the values of wind pressures measured at numerous pressure points on upper and lower surfaces of the trough roof and are reported in the form of cross sectional variation of pressure coefficient and pressure contours. It is observed that the wind pressure distribution on the trough canopy roof is highly influenced by incident wind direction.**

***Index Terms*— Trough Canopy Roof, Wind Incidence Angle, Wind loads, wind Pressure Coefficient.**

I. Introduction

Structural designers refer to relevant standards on wind loads to arrive at correct values of wind forces while designing both low-rise and high-rise buildings. Standards on wind loads of various countries (AS/NZS: 1170.2(2002) [1], ASCE: 7-02-2002[2], BS: 63699(1995)[3], EN: 1991-1-4(2005)[4] and IS:875 (part-3) (1987)[5] provide information about wind loads on trough canopy roofs. But this information is limited for few wind directions and roof slopes only. Further, no research publication is available which describes experimental investigation of wind loads on trough canopy roof. It is therefore, decided to carry out an experimental study on the model of trough canopy roof with varying wind incidence angle. The slope of trough canopy roof was kept as 10°.

II. Materials and Methods

A. Model Description

The prototype building selected for this experiment is a trough canopy roof building having plan area 900m^2. The length, width and eaves height of the building are 30m, 30m and 15m respectively. It is primarily supported by three columns at the center at the eaves. The model is made of Perspex sheet at a scale of 1:100. Thus model dimensions are 300mm x 300mm x 150mm (Fig.1). Each surface is provided with 50 number of pressure taps to obtain a good distribution of pressure on the building model (Fig. 2). Two models of similar dimensions were made one with pressure points on the upper surface and another with pressure points on the lower surface of the trough canopy roof (Fig.3). The pressure points are placed at closer spacing near the edge of the roof model to obtain clear variation of wind pressure near the edges of the roof.

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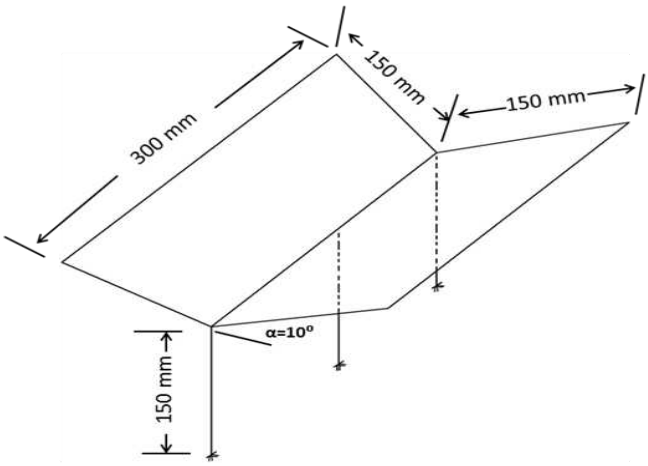

Fig.1 Dimensions of the model

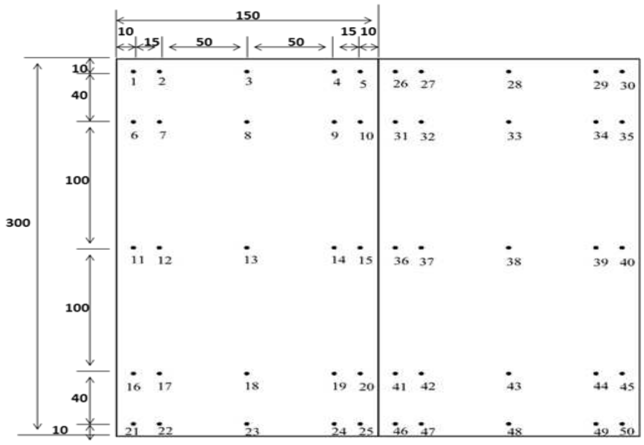

Fig.2 Pressure points on the roof surface of the model

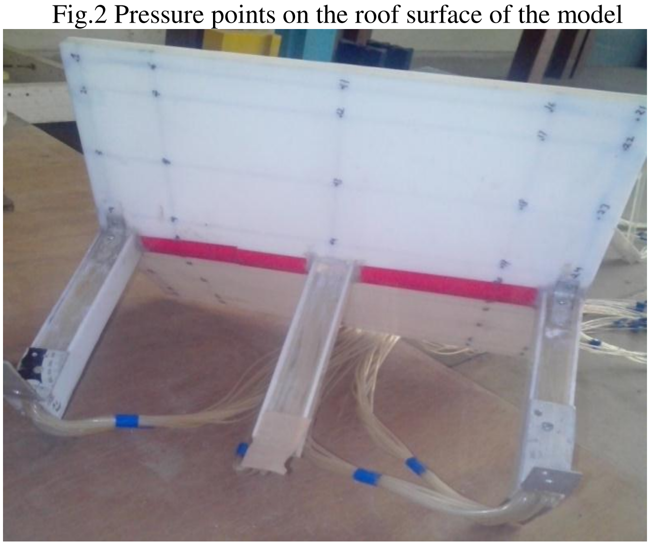

Fig.3 Perspex sheet model of Trough canopy roof

B. Wind Flow Characteristics

The experiments are carried out in open circuit wind tunnel at Indian Institute of Technology Roorkee (India) under boundary layer flow. This wind tunnel has a test section of 15 m length with a cross sectional dimensions of 2m (width) x 2m (height). Floor roughening devices such as barrier wall, vortex generators, cubical blocks of size of 150 mm , 100 mm and 50 mm are used on the upstream side of the test section to achieve mean wind velocity profile corresponding to terrain category 2 as per IS Code. The models are placed on the turn table at a distance of 13.5 m from the upstream edge of the test section.

C. Measurement Technique

Perspex sheet model of trough canopy roof with pressure points on the upper surface is placed at the centre of the turntable in such a way that wind hits the model perpendicular to the ridge i.e. 0^{o} wind incidence angle (Fig.4). Wind pressure values are measured at all the 50 pressure points on the upper surface of the trough canopy roof model. Pressure measurement is repeated for other wind incidence angles namely 15^{o}, 30^{o}, 45^{o}, 60^{o}, 75^{o} and 90^{o} by rotating the turn table. After measuring wind pressure distribution on the upper surface for 7 wind incidence angles, another model with pressure tapping on the lower surface of the roof was placed at the centre of the turn table. Similar procedure was repeated for this model also.

Fig.4 Trough canopy roof model inside wind tunnel

III. RESULTS AND DISCUSSION

Value of mean wind pressure coefficients (Cp) on both lower and upper surfaces of the model are calculated from the measured values of wind pressures. Cross sectional variation of pressure coefficient (Cp) at mid span and pressure contours are plotted. Results of only three wind directions 0^{o}, 45^{o} and 90^{o} are shown (Figs. 5 to 13) due to limitation of space.

It is observed from Figs. 5 to 7 that whereas upper surface of windward portion of trough canopy roof is subjected to suction, lower surface is subjected to pressure at 0^{o} wind incidence angle. Suction is more near the windward edge, which reduces towards the eave. Pressure on the lower surface is almost of the same value. So far as the leeward portion is concerned, upper surface is subjected to pressure which is maximum at the centre. Lower surface of the leeward portion is subjected to suction which reduces from eave to ridge.

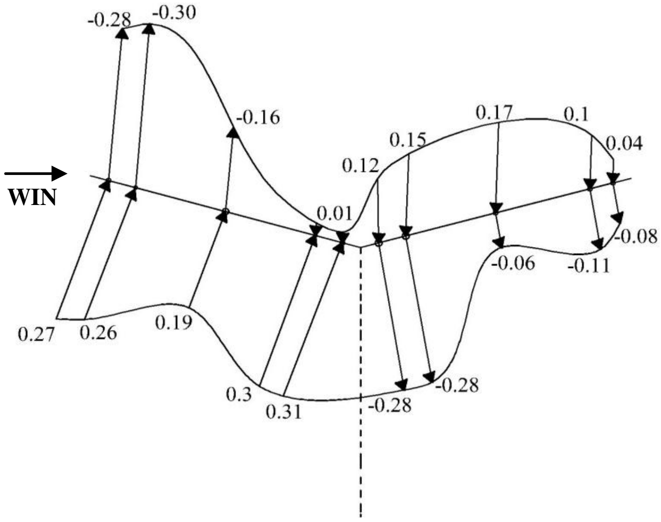

Fig.5 Cross sectional variation of Cp at mid section on upper and lower surface at 0^{o} wind angle.

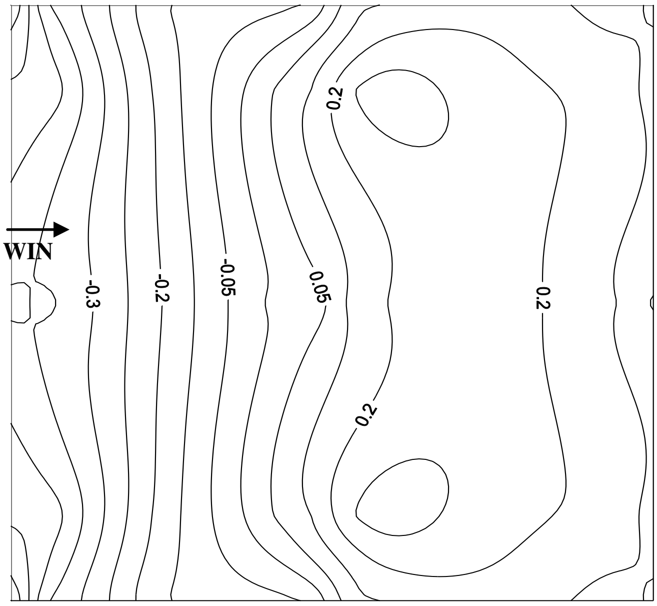

Fig.6 Contours of Cp on upper surface at 0^{o} wind angle.

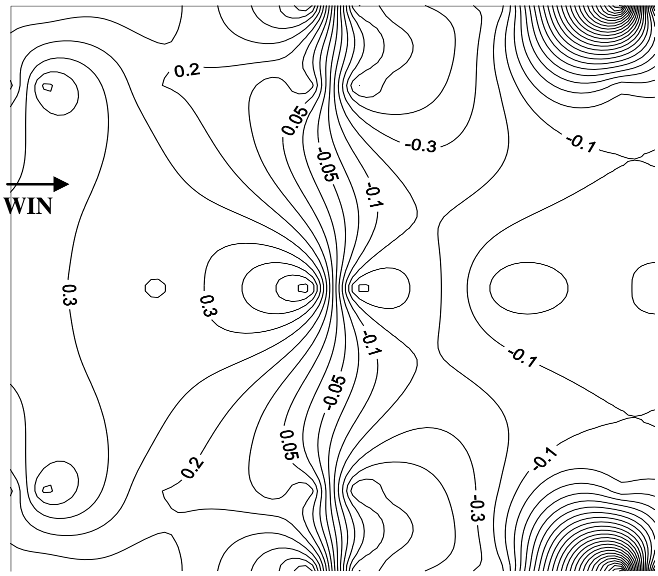

Fig.7 Contours of Cp on lower surface at 0^{o} wind angle.

Figs. 8 to 10 show mean wind pressure coefficient variation on upper and lower surfaces of trough canopy roof at 45^{o}

wind incidence angle. The lower surface is subjected to pressure at windward corner and leeward corner is subjected to pressure.

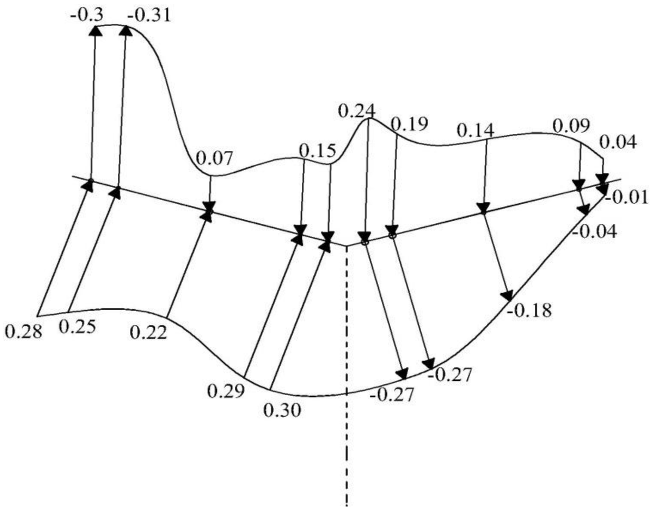

Fig.8 Cross sectional variation of Cp at mid section on upper and lower surface at 45° wind angle.

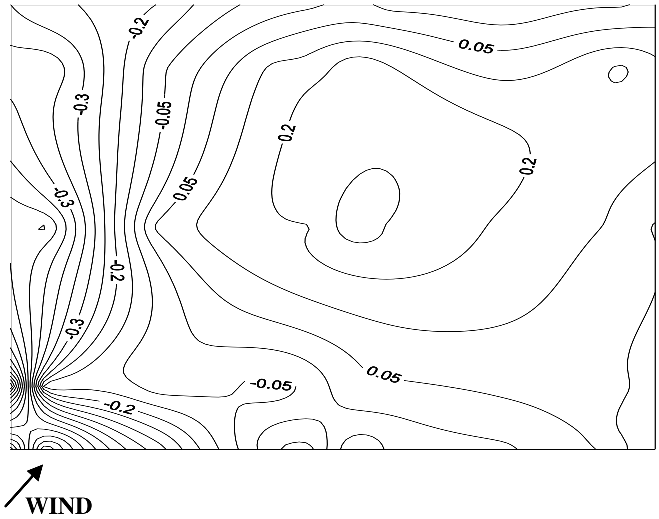

Fig. 9 Contours of Cp on upper surface at 45° wind angle

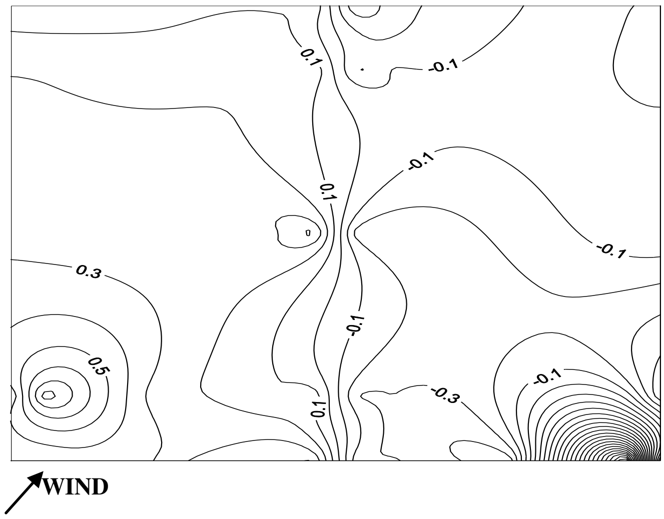

Fig.10 Contours of Cp on lower surface at 45° wind angle.

Figs 11 to 13 show mean wind pressure coefficient variation on upper and lower surfaces of trough canopy roof at 90° wind incidence angle. The lower surface is subjected to suction at windward edge and leeward edge is subjected to suction. However, on the upper surface windward edge is subjected to suction and leeward edge is subjected to pressure.

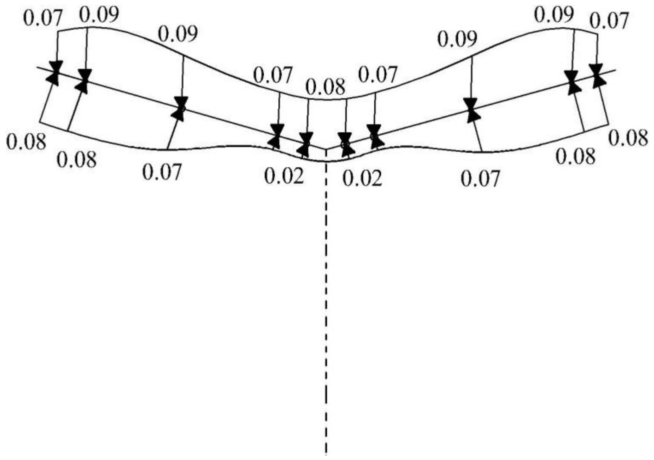

Fig.11 Cross sectional variation of Cp at mid section on upper and lower surface at 90° wind angle.

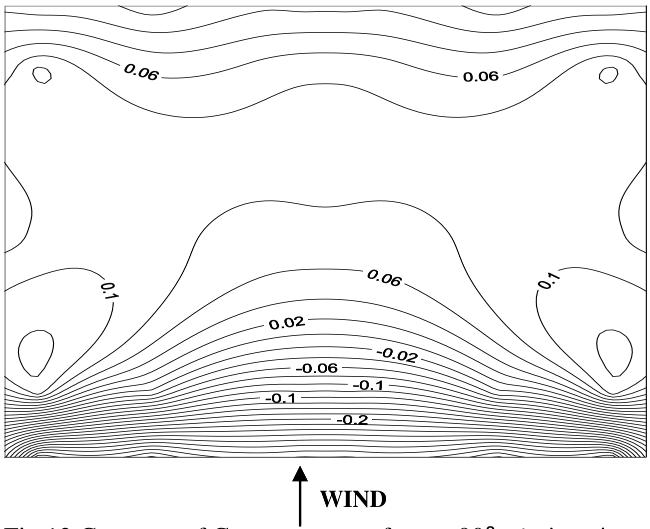

Fig.12 Contours of Cp on upper surface at 90° wind angle

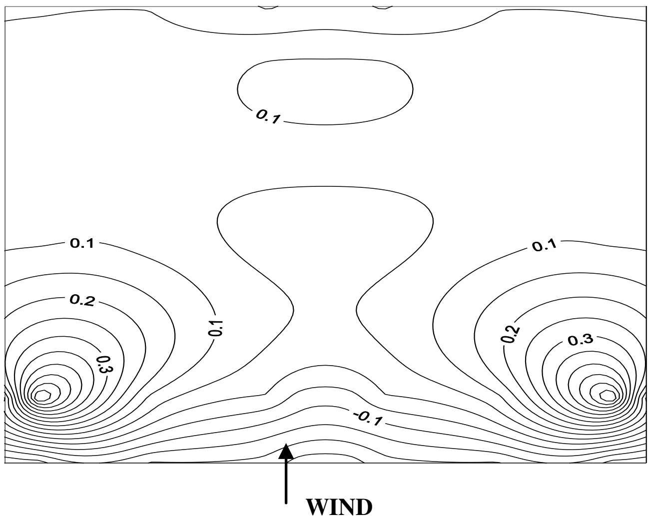

Fig.13 Contours of Cp on lower surface at 90° wind angle.

IV. CONCLUSIONS

The conclusions drawn from the results are presented herein.

1. Wind pressure coefficient on the trough canopy roof is highly influenced by wind incidence angle.
2. Corners of the trough canopy roof are subjected to large variation of wind pressure /suction.
3. Windward edge of the trough canopy roof is subjected to more suction and leeward edge is subjected to more wind pressure. Hence number of fasteners required at the edges will be more to prevent the roof from blowing off due to high suction.

ACKNOWLEDGMENT

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 second author.

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