9th Asia-Pacific Conference on Wind Engineering
Auckland, New Zealand
3-7 December 2017

EFFECT OF SPACING ON WIND PRESSURE DISTRIBUTION ON CIRCULAR CANOPY ROOFS

N. Rani and A. K. Ahuja

Department of Civil Engineering
Indian Institute of Technology Roorkee, Roorkee, 247667, Uttarakhand, India

Abstract

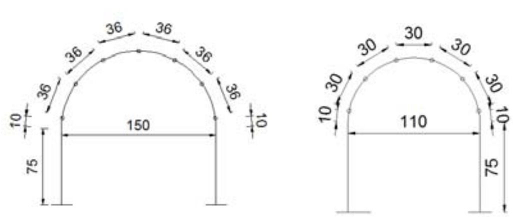
The present study gives the information related to the effect of spacing between two circular canopy roofs on wind pressure distribution. Experiments are carried out in an open circuit boundary layer wind tunnel. Wind pressures are measured on both upper and lower roof surfaces of circular canopy roof model made of Perspex sheet. Models are tested under single wind incidence angle i.e. at 0° but with four spacing between two circular canopy roofs. Values of the wind pressure coefficients on the models with spacing are compared with those on the models having zero spacing. Results of the study are presented in the form of contours and cross sectional variation of mean wind pressure coefficients.

Introduction

Canopy roofs have different shapes like flat, mono-slope, pitched, trough, circular etc. While designing canopy roofs, one needs to know the value of wind pressure coefficients as in case of other structures for its safe design. Whereas information related to wind pressure coefficients on flat, mono-slope, pitched and trough canopy roofs are available in standards on wind loads [1-5] up to some extent, similar information on circular canopy roof is not available. Some of the researches [6-7] have done experimental studies only for single span. Rani and Ahuja [8] has presented test result on multi-span circular canopy roofs without spacing. Present study gives the information about the effect of spacing between two circular canopy roofs.

Details of Models

Two types of models are used during the present study. One model is perxpex sheet model which is used as instrumented model and another one is a plywood model. Scale used for the models is 1:50. Dimensions of the models are shown in figures 1(a) and (b) which show the circumference dimensions of pressure points on upper and lower roof surfaces respectively. Figure 2 shows the 3-d model of circular canopy roof. Scale of the model is so chosen that it does not cause the blockage to flow of wind



(a) (b)

Figure 1. Dimensions of circular canopy roof model

Upper and lower roof surfaces have 49 and 42 pressure points respectively. The positions of pressure points on upper roof surface are shown in figure 3. Upper and lower roof surface have different locations of pressure taps.

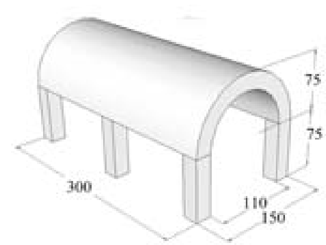


Figure 2. 3-D model of circular canopy roof (All dimensions are in mm)

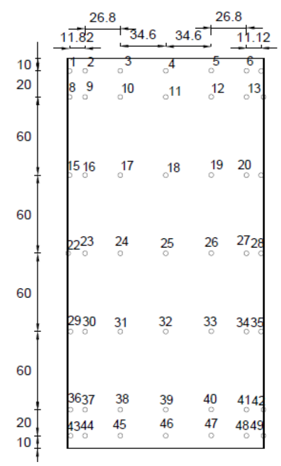


Figure 3. Pressure points on upper roof surface

Wind Flow Characteristics

Experiments for wind pressure distribution on circular canopy roofs are carried out in boundary layer wind tunnel at IIT Roorkee. The length of the wind tunnel is 15m with cross sectional dimension of 2m×2m. Floor roughness is generated with wooden blocks of 150mm, 100mm, 50mm size and vortex generator fins. Models are tested at wind velocity of approximately 10 m/sec measured at 1m height from the floor level of the tunnel. Models are tested under wind simulation condition corresponding to terrain category 2. Figures 4 and 5 show velocity and turbulence intensity profiles inside the tunnel respectively. The wind speed in the wind tunnel is controlled by manually adjusting the outlet control. The tunnel is provided with a turntable of 1.8m diameter at tunnel test section, which allows testing models for varing wind directions.

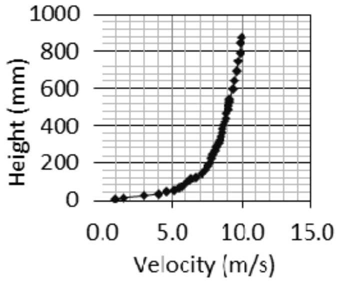


Figure 4. Velocity profile

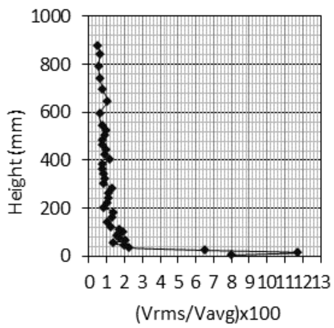


Figure 5. Turbulence intensity

Measurement Technique

Perspex sheet model of the circular canopy roof with rectangular shape is placed at the center of the turntable in such a way that points 1, 8, 15, 22, 29 and 36 fall on windward edge at 0° wind incidence angle. Only one wind incidence angle is considered in the present study, as the focus of the study is effect of spacing on wind pressure distribution on the roof. Wind pressure at each tapping point is measured with the help of pressure transducer for 60 seconds.

While measuring the wind pressure distribution on two-span circular canopy roof, plywood model of the canopy roof without pressure points is placed close to perspex sheet model having pressure points on it (Figure 5). Spacing between two models (S) is varied as 0, 75, 150, 225, 300 mm corresponding to s/w ratio equal to 0, 0.5, 1.0, 1.5 and 2.0 (where w=width of the canopy roof) to study the effect of spacing between them (Figure 6). Values of mean wind pressure coefficients are evaluated from the measured values of wind pressures. Although pressure measurements are taken on both upper and lower surfaces of the Perspex sheet model, results of only upper roof are reported in the paper due to paucity of space.

Figure 6. Circular canopy roof inside the wind tunnel

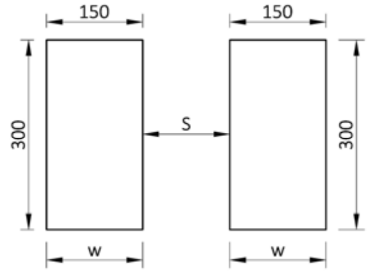


Figure 7. Plan of circular canopy roof

Results and Discussion

Case 1 (Isolated)

Figure 8 shows the cross sectional variation on single span circular canopy roof for 0° wind incidence angle. It is observed that windward eave is subjected to pressure which changes to suction with its maximum value near the apex. Then suction decreases towards leeward eave. Maximum value of suction is -1.6 at section 4-4. Figure 9 shows contours for 0° wind incidence angle.

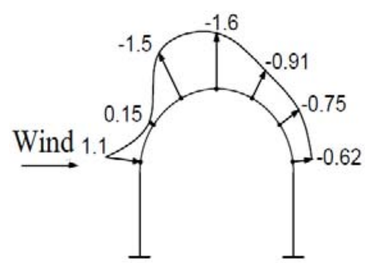


Figure 8. Cross sectional variation of mean wind pressure coefficients at section 4-4 on upper roof surface for isolated roof

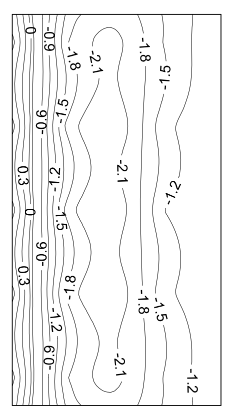


Figure 9. Contours of mean wind pressure coefficients on upper roof surface for isolated roof

Case 2 (s/w = 0.0)

When wind hits the model perpendicular to its length, i.e. at 0° wind incidence angle, windward side of first span is subjected to pressure near the eave (Figure 10). Later pressure changes to suction from windward to leeward direction. Maximum value of Cp is -1.4 at section 4-4 in two span. Suction increases from windward side to ridge side and again decreases towards leeward side. Suction is higher at first span as compared to second span. Same variation of pressure coefficients is shown by contours in figure 11.

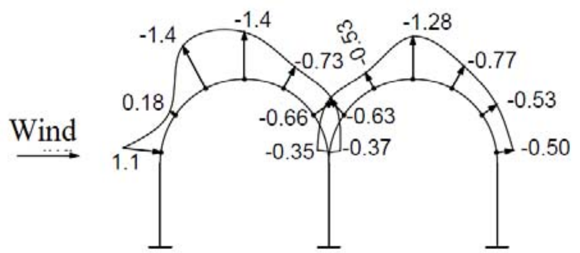


Figure 10. Cross sectional variation of mean wind pressure coefficients at section 4-4 on upper roof surface for s/w=0.0

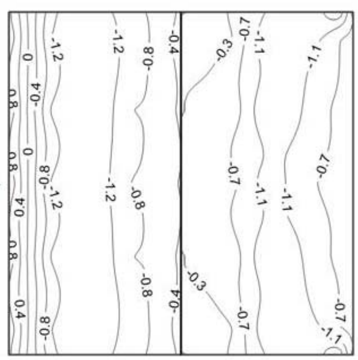


Figure 11. Contours of mean wind pressure coefficients on upper roof surface for s/w=0.0

Case 3 (s/w = 0.5)

Figures 12 and 13 show the effect of 75mm spacing on second span. The windward side roof have pressure on one third of the total width of the roof. Leeward roof is also subjected to pressure near windward eave. But as it reaches to the ridge of the roof, the pressure changes into suction. Suction is maximum at ridge. After that suction decreases towards leeward direction. Maximum value of suction on both first and second span is -1.4 and -1.35 respectively at section 4-4.

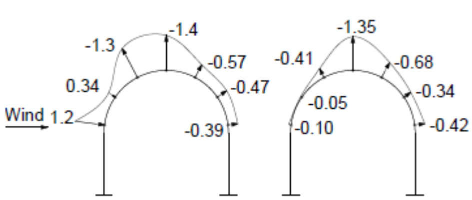


Figure 12. Cross sectional variation of mean wind pressure coefficients at section 4-4 on upper roof surface for s/w =0.5

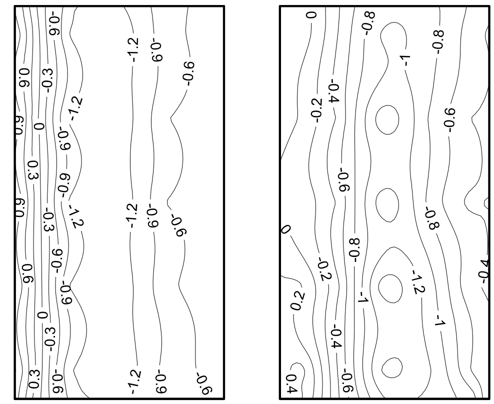


Figure 13. Contours of mean wind pressure coefficients on upper roof surface of circular canopy roof for s/w =0.5

Case 4 (s/w = 1.0)

Windward portion of second span is subjected to greater pressure in case of 150 mm spacing. (Figures 14 and 15).

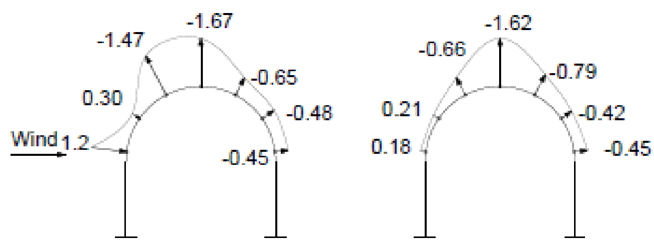


Figure 14. Cross sectional variation of mean wind pressure coefficients at section 4-4 on upper roof surface for s/w =1.0

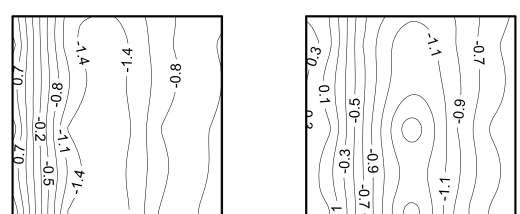


Figure 15. Contours of mean wind pressure coefficients on upper roof surface of circular canopy roof for s/w =1.0

Case 5 (s/w = 1.5)

As the spacing further changes from 150mm to 225mm, the value of pressure on second span increases further on windward side of second span (Figures 16 and 17).

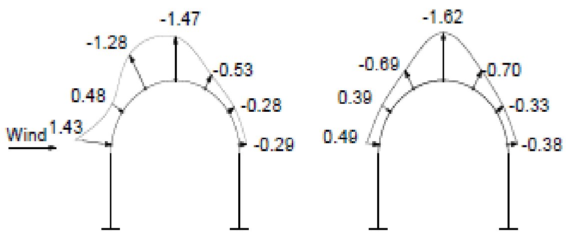


Figure 16. Cross sectional variation of mean wind pressure coefficients at section 4-4 on upper roof surface for s/w =1.5

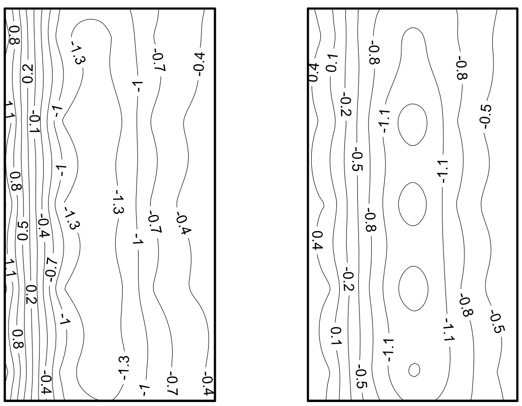


Figure 17. Contours of mean wind pressure coefficients on upper roof surface of circular canopy roof for s/w =1.5

Case 6 (s/w = 2.0)

Shielding effect gets reduced with further increase in spacing between two spans to 300mm (Figures 18 and 19).

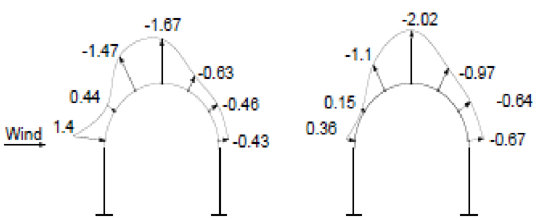


Figure 18. Cross sectional variation of mean wind pressure coefficients at section 4-4 on upper roof surface for s/w =2.0

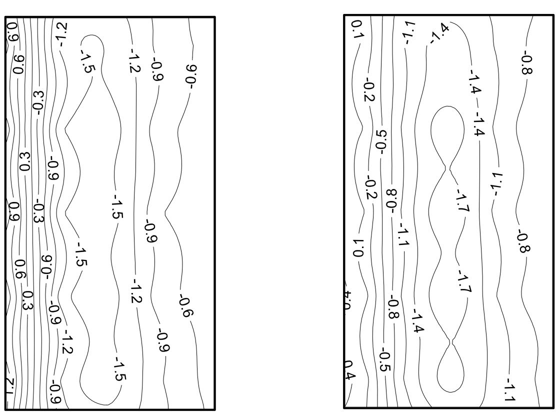


Figure 19. Contours of mean wind pressure coefficients on upper roof surface of circular canopy roof for s/w =2

Conclusions

- Wind pressure distribution on circular canopy roof is highly affected by spacing between the two circular roof.
- Windward side has pressure and leeward side has suction.
- Suction is maximum at ridge.
- As the spacing between two spans increases, suction on windward side of leeward span decreases and becomes pressure at large spacing.

Acknowledgments

The work presented in this paper is part of the research work being done by the first author for her Ph.D. degree under the supervision of second author.

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