AIRFLOW AROUND CONIC TENSILE MEMBRANE STRUCTURES

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Sophisticated analytical models and computer software have facilitated the structural design of tensile membrane structures and this has produced a diverse and complex range of design and form solutions. The climate inside a typical fabric membrane enclosure is dependent on factors such as the shape (having a significant clear height) and the thermal properties of the thin "skin", which differ considerably from traditional or more conventional "heavy" construction. However, there has been little consideration of the effect that these forms "shapes" have on their immediate environment, from the point of view of human comfort, even for the most basic of shapes. Tensile membrane structures can have an attractive dramatic effect and easily span a large area. In addition to the lighting and shading functions normally associated with tensile membrane skins, the topology of the construction type offers exciting opportunities to lend additional functionality and higher levels of comfort to the enclosure (ElNokaly *et al*, 2002).

This paper describes the results of wind tunnel visualization and monitoring of the airflow patterns around and under conic tensile membrane structures covering open and semi-enclosed spaces. The experiments were conducted using a number of physical models representing a simple conical membrane structure. The study was designed primarily in order to ascertain the potential of conic membranes for modifying the microclimate and improving human comfort in their immediate vicinity.

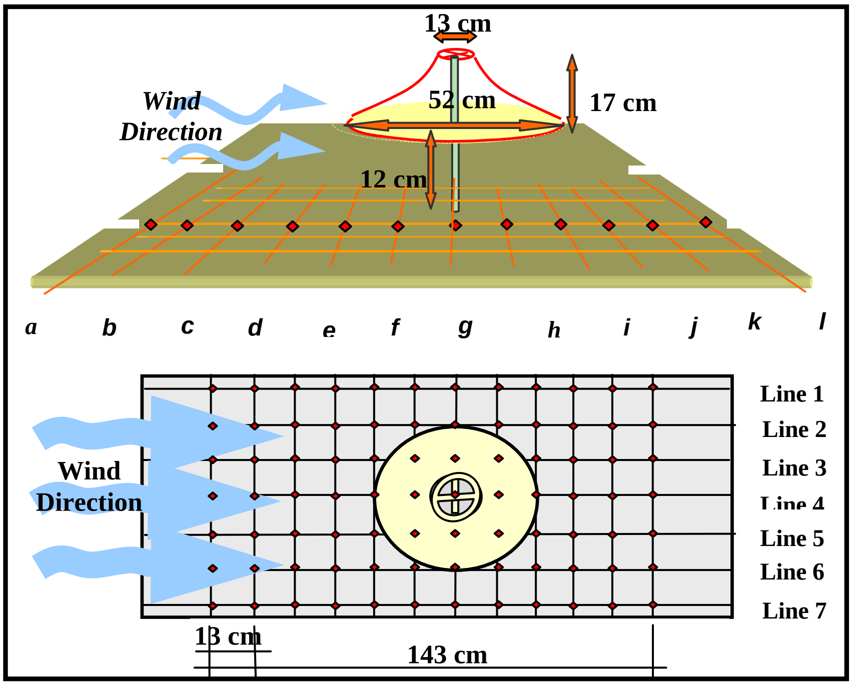

Figure 1. Perspective and plan of the conical membrane structure and the grid of air velocity measuring points

Figure 1 shows a perspective of the conical membrane model and the grid of measurement points using the letters (**a**, **b**, **c**,…) to denote rows, and the numbers (**1**, **2**, **3**…) to denote columns on the grid. The mast support for the cone is located at grid position **g4**.

The influence of factors such as the shape of the cone (height to width ratio), height of the membrane above the ground surface, inclination of the conical membrane from the horizontal plane and the provision (or not) of a vent at the apex are considered. Horizontal, inclined, open and closed apex cases were explored for a variety of cone rise/diameter ratios and apex height/diameter ratios. Monitoring of the air velocity was carried out on a grid of 84 different points as shown in figure 1 for each configuration. Using these results, the possible use of a conic tensile membrane structure's topology and orientation to enhance ventilation rates and airflow velocities within the covered space is discussed. This study is carried out using a small open jet wind tunnel developed for teaching purposes by the BRE (Building Research Establishment) (Clarke, 1998).

a. **b.** **c.**

Figure 2. (a) Hot wire anemometer; (b) the conical membrane model; and (c) the model when inclined

Figure 2(a) shows the hot wire anemometer (an Air Velocity Meter, "tsi" Model 1650) used in measuring the air velocities at the grid points. Figure 2(b) shows the 52 cm diameter conical membrane model with open apex and 17cm high. Figure 2(c) shows the 17cm high cone in the inverted position with the smaller ring at 12cm above the base board.

Preliminary results of the investigation show that higher airflow velocities are achieved within the enclosure under certain conditions; airflow velocity generally tends to be lower in the vicinity of an opened apex cone when compared to a similar closed apex cone. The possible use of the fabric's topology and orientation in conical fabric structures, particularly to enhance ventilation rates and airflow velocities within the covered space and around buildings in its immediate vicinity has been demonstrated. This improved ventilation may enhance the comfort of occupants of the membrane enclosure, particularly in hot climates and reduce the demand for mechanical cooling systems (and consequently energy consumption). Detailed results and conclusions are presented in the final paper.

It is concluded that there is a need for further research in this area, in order to fully realise the potential benefits offered by tensile membrane structures for modifying airflows in their immediate vicinity.

References

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