PRACTICAL WIND-RESISTANT DESIGN OF LARGE SPACE FLEXIBLE CABLE NET

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ABSTRACT

The wind tunnel tests on rigid models of saddle-shape cable roofs with and without enclosed wall were carried out in exposure categories B and D in a wind tunnel by using the synchronous multi-pressure scanning technique. This paper has focused the discussion on the study of mean and fluctuating wind; wind response in time-domain solution and frequency domain analysis of saddle-shape cable net. The influences of the enclosed wall and difference terrain types on wind pressure distribution characteristics were also discussed in detail by comparing the shape factors and fluctuating wind pressure RMS coefficient of the saddle roof model with and without enclosed wall by using wind pressure data obtained from the wind tunnel test in exposure categories B and D. In the end, wind induced response of the flexible cable net roof was investigated taking into account the influence of enclosed wall, cable forces and wind velocity.

KEYWORDS: CABLE NET, WIND TUNNEL TEST, WIND PRESSURE, WIND LOAD

Introduction

Cables are very efficient structural system and hence have been widely used in many long-span roof structures, including gymnasiums and exhibition centers etc. Flexible cable nets become increasing sensitive to wind, and it becomes the dominant factor in the structural design, since cables are light, very flexible and lightly damped, usually have various dynamic problems, therefore analysis of the wind load and response is very important.

Cables are generally considered as tension elements, therefore their strength in flexure and compression are negligible. Tension structures are characterized by non-linear geometric hardening, which results in a less proportional increase of stress in elements in relation to increasing external loads. Finite element models will be developed to represent cables; considerations will be given to the various nonlinearities associated with cable structures, such as large deformations, nonlinear stress-strain relationships and non-conservative loadings.
Wind Tunnel Tests

The experiments of the saddle roof with and without were carried out in a closed-circuit-type wind tunnel with a working section (15m long, 3m wide and 2 m high) at Tong Ji University, Shanghai China. The wind tunnel model of saddle roofs without and with enclose wall at a scaling ratio of 1/50 is shown in Fig.1 and Fig.2 respectively.

Fig. 1 Wind tunnel model without enclose wall  Fig. 2 Wind tunnel model with enclose wall

Mean wind pressure

The mean wind pressure shape factors were investigated based on the wind pressure data obtained from the wind tunnel test. The distribution characteristics of the shape factors in the two different wind field conditions and the influences of the enclosed wall on wind pressure distribution were discussed. Fig.3 shows the mean wind pressure shape factor distributions for an azimuth of 0° on saddle roof with and without enclose wall in exposure categories B.

Fig. 3 Distribution of shape factors on saddle roof with enclose wall and without enclose in exposure categories B

Fluctuating wind pressure

In order to determine the overall stochastic characteristics of wind loads on the saddle roof, a comprehensive experimental research, of local wind pressure fluctuations on low building roofs has been carried out, by testing a various building models exposed to open and suburban boundary-layer flows in various wind directions. The analysis of pressure data indicates that the pressure fluctuations are sensitive to roof geometry and wind directions. Fig. 4 shows the distributions of the root-mean-square (RMS) fluctuating wind pressure coefficients for an azimuth of 0° on saddle roof with and without enclose wall in exposure categories B.
Analysis of dynamic response

In light roof structures, especially those with low inherent stiffness, gusts and turbulence may cause vibration or flutter of a local portion of the cable net roof. Therefore, the design of the cable roofs requires an examination of the dynamic behavior that is necessary to ensure safe design. The wind-induced responses of the saddle roof with and without enclosure were analyzed in time domain by ANSYS software using finite element LINK10. The influences of the enclosed wall, cable forces and wind velocity on wind response were also discussed in detail. Fig. 5 and Fig. 6 show the displacement response time history on tap 111 and tap 13 based on mean wind displacement which is initial balance location, respectively.

Fig. 5 Displacement response time history on tap 111
Fig. 6 Displacement response time history on tap 13

Fig. 7 and Fig. 8 show the displacement response of the tap 111 and tap 13 on the saddle net roof with different cable force respectively. We can see the response amplitude decreases with the increase of the cable force. The nonlinear of the cable net is different with the cable force values, it directly influences the wind response results of the cable net roofs.
Saddle cable net roof located in different area has different reference wind pressure in analysis of the wind induced response. Fig. 9 shows the displacement response time history of the node 111 on the cable net roof under three reference wind pressures. Fig 10 gives displacement RMS response on the some typical nodes. Comparison of the response result concludes that displacement response is linear increase with the reference wind pressure.

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