Development for Comprehensive Health Monitoring System for a New Air-supported Membrane Structure Hall

Wujun Chen*, Yue Yin[a], Qin Wang[b], Jianhui Hu[a]

*Space Structure Research Center, Department of Civil Engineering, Shanghai Jiao Tong University
Room A302, Ruth Mulan Chu Chao Building, 800 Dongchuan Road, Shanghai, China
E-mail: cwj@sjtu.edu.cn

[a] Space Structure Research Center, Department of Civil Engineering, Shanghai Jiao Tong University
[b] Broadwell (Shenzhen) Technology Co., Ltd.

Abstract

Air-supported membrane structure has been widely used in large-span building in recent years due to its prior properties including low-weight, convenient installation and authentic appearance. Unlike steel and concrete structure, membrane structure tends to be more vulnerable to harsh external environment and catastrophic failure from structural vibration. In general, internal pressure is monitored in almost all the air-supported membrane structure in order to adjust the value of the pressure in response to external environmental load. However, current pressure regulation in air-supported membrane structure is based on several preset operating modes which are not accurate enough to reflect real conditions. In addition, it is also necessary to monitor other parameters that embodies dynamic properties and internal thermal environment to maintain comprehensive health of the membrane structure.

In this paper, a comprehensive health monitoring system for a new air-supported membrane structure hall is developed. This monitoring system is consisted of three sub-systems including structural, thermal and meteorological monitoring sub-system. Structural monitoring sub-system is installed on the external membrane surface to measure dynamic properties of the hall. In this sub-system, three three-dimensional accelerometers, three wind pressure sensors, three GNSS (Global Navigation Satellite System) mobile base stations, four strain gauges are used to measure the acceleration, wind pressure, membrane displacement, and cable strain, respectively. 23 wireless temperature & humidity sensors compose thermal monitoring sub-system to gather data of internal temperature and humidity of the hall. Meteorological monitoring sub-system is set near the hall to obtain environmental parameters such as temperature, humidity, wind speed, wind direction, irradiation, precipitation and so on, providing reference for structural performance and thermal environment analysis. It is worthy to mention that all the sensors of sub-systems are placed at specified positions to cover all the membrane hall considering factors such as three-dimensional spatial dimension of the hall, external environment. Besides, the data provided by structural monitoring sub-system is transmitted via signal wire connected to receivers while other sensors can transmit data signal using wireless technology. All the receivers of the monitoring system are put in an equipment room nearby.

Analysis of long-term monitoring data can definitely help maintain good health for a new air-supported membrane structure hall: 1) Dynamic properties under different environment condition could be obtained, which is beneficial to design a complete active pressure control system for air-supported membrane structure to resist external load. 2) Study of thermal environment in the membrane hall is useful for ventilation organization and air conditioning management, which can not only promote energy efficiency but also preserve a comfortable thermal environment for human. 3) Analysis of structural and thermal behaviors can be used to improve structural analysis methodology, design theory and technical order of membrane structure.