Indoor Thermal Performance of Enclosed Large-Span Membrane Stadiums

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ABSTRACT

Membrane stadiums with excellent light-weight, high-transmittance and self-clean properties have attracted considerable attention in recent decades, such as Allianz Arena (Germany), National Aquatics Center (China). As public places for holding sports events, indoor environment, including temperature, humidity and velocity fluctuating with solar irradiance, are indispensable for evaluating thermal comfort. However, these performance of enclosed large-span membrane stadiums are not well-understood. This paper focused on measurement of winter indoor parameters and determination of thermal characteristics of a typical enclosed PTFE stadium under sunny and sunny to cloudy conditions.

An experimental study considering time- and location-dependent effects was carried out. The location effect was considered by horizontal (east and south) and the vertical (three stands) positions with wireless thermocouples. The time effect was investigated by sunny and sunny to cloudy conditions on three similar days. The measured parameters incorporated solar irradiance, air velocity, temperature, relative humidity. It is observed that solar irradiation fluctuated dramatically on cloudy days and overall trend between solar irradiation and air temperature was similar. Air speed lower than 0.3 m/s indicated that natural validation could not significantly influence indoor thermal environment of enclosed membrane stadium. Air temperatures measured in the south were higher than those at the same location in the east. Moreover, air temperature increased from 1st to 3rd tier and peak temperature at lower tier appeared later than that at higher tier. To understand these experimental observations with reasonable explanations, unsteady heat transfer theory with periodical boundary conditions was employed in this study. Temperature differences between 2nd and 3rd tiers was greater than those between 1st and 2nd tiers, especially on sunny days. Furthermore, thermal comfort index, new standard effective temperature and operative temperature, were used to evaluate thermal comfort of enclosed membrane stadiums.

In general, this study could provide essential data for understanding temperature characteristics and assessing thermal comfort of enclosed membrane stadiums.

KEYWORDS

Enclosed membrane stadium; PTFE membrane; temperature characteristics; thermal comfort; unsteady heat transfer theory.

REFERENCES