

Experiment and SHM on the membrane structure of Shanghai Kunshan Football Stadium

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ABSTRACT

Kunshan football stadium, which will be put into use soon, is composed of 36 membrane elements, 36 steel trusses and reinforced concrete grandstand. The PTFE membrane, the concrete double-column system and the steel truss system form the surface and the bone of a huge fan in the shape, making the overlooking stadium like a folding fan with unique regional characteristics. The most important feature of the stadium is the use of a large area of PTFE membranes, which make the overall structure sensitive to wind and snow loads. In order to ensure the safety of the structure, the bearing capacity of the membrane element was verified by experiments. On the other hand, the wind pressure sensor and snow pressure sensor are set on the roof membrane system to carry out monitoring real-timely during the operation of the structure, and warnings will be put forward once the design load is exceeded. Meanwhile, strain sensors, inclination sensors and acceleration sensors are set on the roof truss which is considered as the fixed end of the membrane. So the stress, deformation and vibration frequency of the truss are monitored in real time to evaluate the evolution trend of the overall stress state of the membrane and truss system. According to the data measured by the strain sensor installed as early as the construction period, the stress of the truss is stable during the construction stage, and the stress changes little before and after the membrane installation, and there is a large safety reserve. The other sensors are still being installed and will be put into use shortly.

即将投入使用的昆山足球场，由 36 组膜单元及钢桁架、混凝土看台构成。其中，轻柔通透的 PTFE 膜结构与混凝土双柱、钢桁架在外形上构成了扇面和扇骨，使得昆山足球场如一副展开的极具地方特色的苏工折扇。该场馆的最大特色是采用了大量的通透的 PTFE 膜，膜结构的受力特点导致整体结构对风荷载及雪荷载敏感。为保证结构的安全，一方面，对膜单元的承载能力进行了试验验证；另一方面，在屋面膜上设置了风压传感器、雪压传感器，对结构使用阶段，屋面膜所受的风荷载和雪荷载进行实时监测，一旦超出设计荷载则提出安全预警。与此同时，在膜的固定端—屋面桁架上设置了应力应变传感器、倾角传感器及加速度传感器，对桁架的应力、变形及自振频率等进行实时监测，以评估柔性-刚性结构的整体受力状态的演变趋势。由膜单元的承载力试验可知，该项目采用的 PTFE 膜材构成的膜单元的承载能力满足设计要求。由在施工期已安置在桁架上的应变传感器测得的数据可知，桁架受力稳定，在膜安装前后受力变化较小，有较大的安全储备。其余几类传感器仍在安装过程中，将于不久后正式投入使用。