Stadia & large span roof structures

WIND ENGINEERING & ARCHITECTURAL AERODYNAMICS
Sports stadia and large span roof structures of increasingly unprecedented scale are being designed, incorporating landmark architecture and innovative structural design. Cost effective design of large span roof structures of complex external envelope is dictating light-weight design, making these roof structures highly sensitive to loading such as wind and snow. In order for sophisticated 3D structural modelling to deliver efficient structural design, accurate loading scenarios are required for wind that account for complex fluid-structure interactions including wind driven dynamic effects. Wind related environmental effects such as pitch microclimate and spectator comfort and external microclimate all require careful consideration from an early stage in design. BMT Fluid Mechanics (BMT) operates a highly specialised and resourceful stadia and large roof structures group that provides designers with a comprehensive portfolio of consultancy services for structural, serviceability and environmental design based on substantial in house capabilities and experience for boundary layer wind tunnel testing and numerical modelling.

**KEY SERVICES**
- Wind climate analysis
- Roof structural load & dynamic response analysis
- Pedestrian wind comfort analysis / environmental impact assessment
- Façade pressure analysis
- Snow & sand accumulation / drift analysis
- Spectator comfort analysis
- Pitch microclimate analysis
- Ball flight analysis

**KEY BENEFITS**
- Cost-effective structural design
- Cost-effective façade design
- Optimised occupant / spectator comfort
- External microclimate control
- Interactive solution development
- Iterative design optimisation

**WIND CLIMATE**

The specification of design wind speeds for structural, serviceability and environmental design requires careful analysis of long-term wind statistics. BMT has access to global wind record databases, which provide long-term wind statistics for extreme wind events including synoptic and non-synoptic wind patterns including e.g. Typhoon, Shamal, and Thunderstorm.

By application of sophisticated industry-standard wind models of the atmospheric boundary layer and extreme value statistical analysis of storm records, site-specific wind climate models are generated for each development that can also provide detailed resolution of wind directionality and probability of occurrence.

Where required, generic wind models are complemented through detailed modelling of non-synoptic wind patterns using approaches such as topography modelling and Mesoscale models. Wind climate studies are accepted throughout the world by local building departments and regulatory bodies and deliver a robust basis for reduction of inherent conservatism in design codes.
Dynamic wind loading is in many cases a governing parameter in the design of the primary and secondary structural support systems of the roof of large sports stadia and large span roof structures. Cost efficient design of these components requires reliable quantification of these wind parameters.

Boundary layer wind tunnel testing based on high frequency pressure integration (HFPi) techniques allow accurate determination of critical loading scenarios dictating for the structural stiffness of the roof. In particular, this technique allows detailed analysis of structural load effects such as net uplift / downforce and vertical shear cases based on structural influence lines thereby delivering loading scenarios for structural design which are substantially less conservative than applicable codes of practice.

Wind driven snow and sand accumulation and drift can cause significant loading on large span roof structures. Codified methodology available to designers is often rather simplistic and when applied to complex roof arrangements and can lead to overly conservative structural design solutions.

BMT have purposely developed a number of sophisticated physical and numerical modelling techniques including aeolian transport and particle tracking models to provide designers with the opportunity to study the effects in greater detail and to derive more bespoke quantification of key loading scenarios.
BMT’s interactive approach to pedestrian wind comfort studies allows designers to develop wind mitigation schemes and validate these for effectiveness through time and cost efficient interactive wind tunnel test work-shop days.

In addition, numerical models can be applied to quantify sunlight / overshadowing effects and coupled dynamic thermal modelling allows thermal comfort to be determined. BMT’s technical and interpretative reporting is compatible with Environmental Impact Assessment formats required by planning authorities.

Cladding pressures on glazed facades and roof cladding systems can be accurately measured using detailed small-scale wind tunnel models instrumented with pressure taps.

Internal pressures can be quantified using computational internal airflow models. Sophisticated 3D contouring software allowing automated on-line presentation of surface pressure data for complex external building form allows the façade pressures to be effectively displayed in a way that is easily digested into cost effective façade/cladding system design by façade contractors.

Generating controlled external and internal microclimate in the vicinity of stadia and large span roof structures by purposeful development of wind mitigation schemes that protect from the unfavourable action of downdrafts and ground level wind tunneling is key to the commercial success of external recreational spaces as well as internal seating areas and is key to ensuring user comfort.

BMT operates multiple channel wind speed sensing systems that allow the wind speed up to be quantified in severity and spatial extent in key pedestrian areas and for pedestrian wind comfort to be defined in terms of suitability for planned uses.
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