PHOENICS Case Study: Pedestrian comfort beneath metal canopy with foliage surround

August 2021, revised October 2021

CHAM was asked by Architectural Studio designer, Elias Sanchez to simulate the effect of solar shading upon pedestrians occupying an area beneath a canopy with an intricate metal roof design situated within a park in Culiacán, Sinaloa, Mexico, where summer temperatures often exceed 35^{o}C with high levels of relative humidity. The client's interest focused upon the solar incidence and shadow behaviour based upon meteorological data. The requirement was to determine the thermal comfort experienced by pedestrians passing underneath, or seated around, an open plaza consisting of a partially-open metal roof canopy built upon a stone base and grass surround.

The purpose was to ascertain the occupants' overall comfort, taking into consideration the prevailing environmental conditions - i.e. the wind, temperature and relative humidity - whilst including the added effect of shading (and potential cooling) from surrounding trees and novel artificial star-shaped lamp posts. The design was supplied in CAD form as a 3D model in 3DS format and imported directly into PHOENICS/FLAIR.

CAD model displayed in PHOENICS-VR with shading activated

The case made use of several features which are inbuilt to FLAIR to simplify greatly the process of problem definition: - The SUN object determines the appropriate solar load and angles and calculates the areas of shading that can then be used in conjunction with IMMERSOL to determine the radiative heat transfer from all the surfaces. The WIND object controls the setup of the atmospheric boundary layer, the temperature and the humidity levels. The trees are also modelled using a FOLIAGE object, which implements a drag model to these areas, applies the correct shading and a source of "coolth", as naturally the trees will extract some of the heat from the surrounding air.

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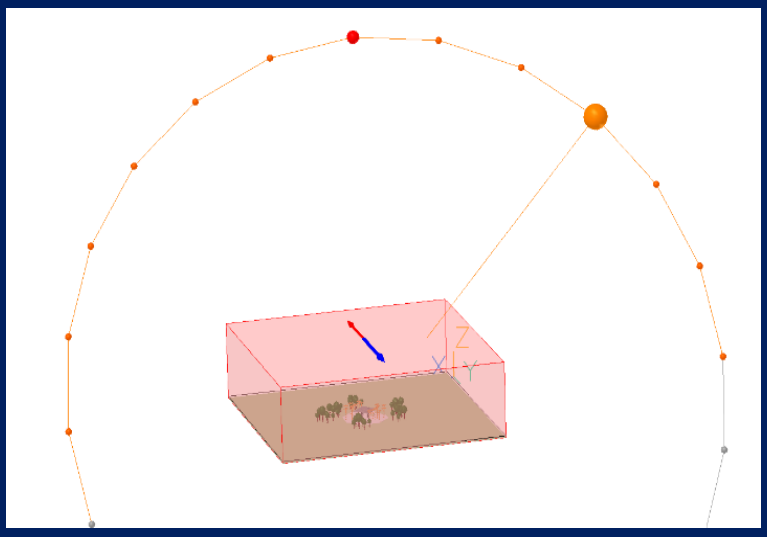
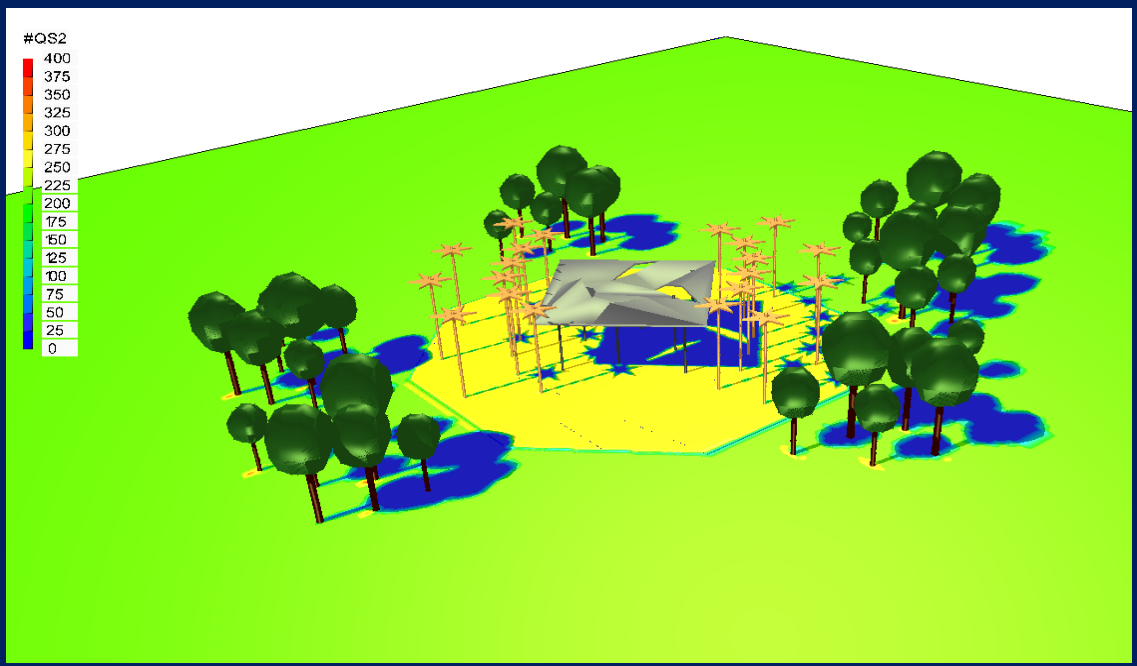


Sun & wind strength and direction added via the Sun & Wind objects

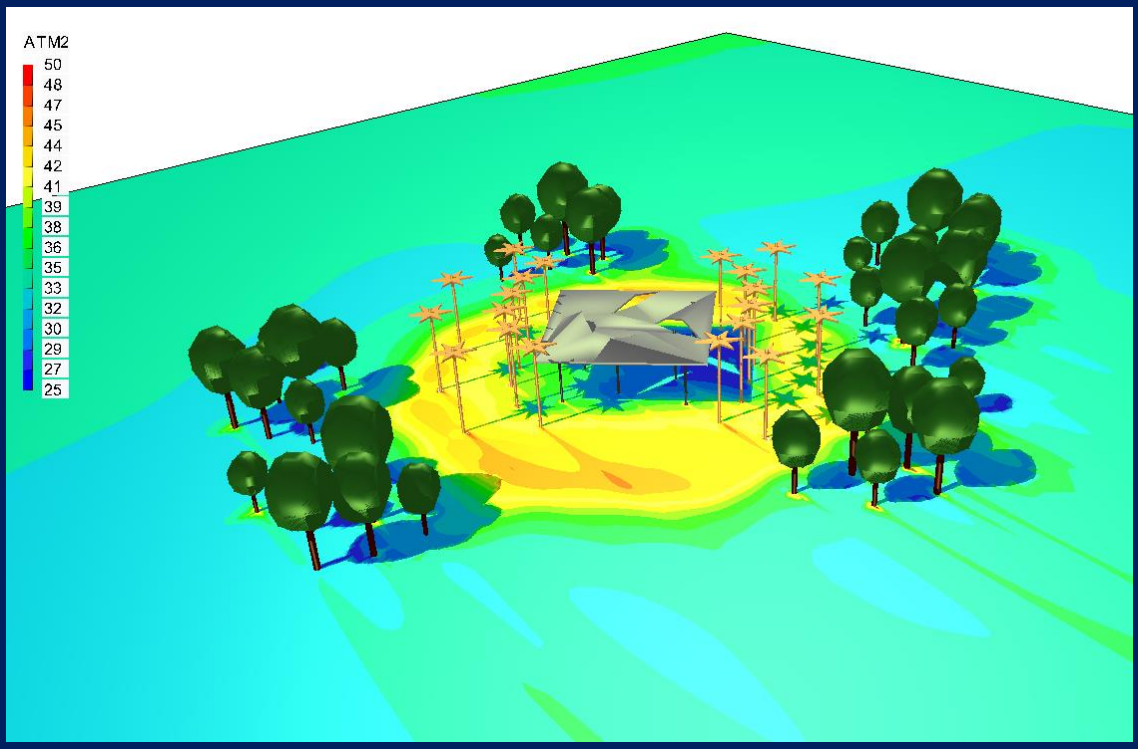
The capability of PHOENICS/Flair to interface with third party software products (such as EnergyPlus™) to extract the meteorological data for a specific location was not used on this occasion, and such data was added manually via the GUI.

All these variables then come together to answer the client's original question: How effective is their roof design at providing a comfortable environment for people in the park? This can be measured directly using one of FLAIR's available comfort indices, in this case the Apparent Temperature, which takes into account the local air temperature and velocity, radiant temperature from the sun plus the metal roof, the amount of radiation absorbed by a person depending on clothing and the humidity level to yield the "Feels like" temperature so often quoted in weather reports.

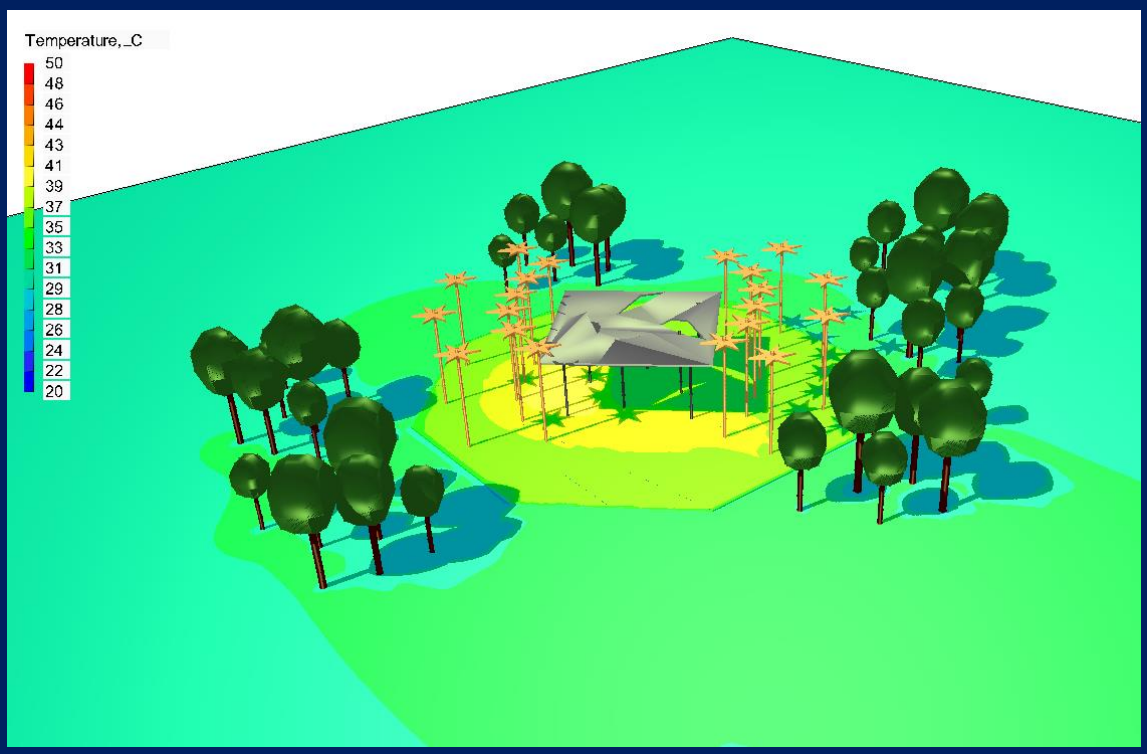


Solar radiation

In order to make a true comparison of the results of the simulation with measured data, it is usual to run the CFD model transiently to capture the heating and cooling processes over time. For the purpose of canopy design however, this case can be run as a steady-state simulation to represent the meteorological effects taken as a snapshot in time, employing a 'solar absorption' factor to ascertain a reasonable trend.



Apparent temperature [CHAM Oct 2021 revision] @ 1.8m (with shading)



Ground temperature (with shading)

PHOENICS/FLAIR can now also be accessed 'on the cloud' via the Microsoft Azure Marketplace, allowing clients the full capability of urban CFD modelling using high-performance processing power and without the need for either software download or licence purchase. See:
http://www.cham.co.uk/_docs/pdfs/phoenics_docs/PHOENICS-OTC2021.pdf