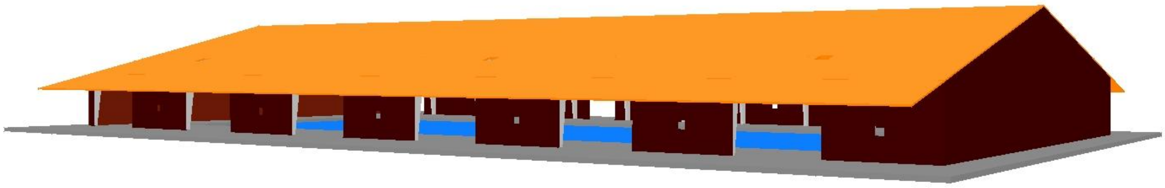
CHAM Limited
Pioneering CFD Software for Education & Industry

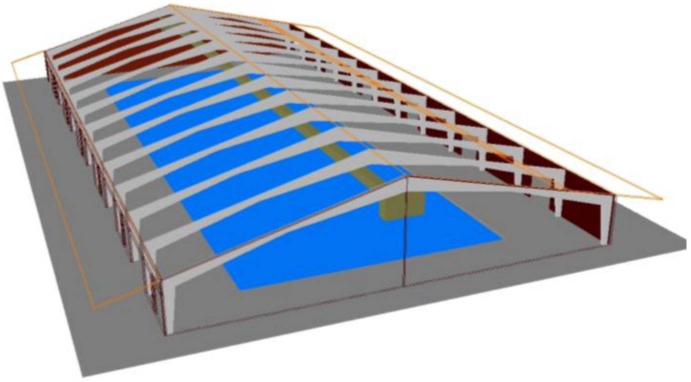
CHAM Case Study – Natatorium Ventilation

Swimming Pool complex, Texas, USA

Two steady-state simulations of a natatorium were carried out for Kirksey, an architecture firm based in Houston, to analyze flow, temperature and humidity for best and worst case wind scenarios with a combination of natural and forced ventilation.



Thermal comfort parameters (Predicted Mean Vote and Predicted Percent Dissatisfied) and indoor air quality parameters - mean age of air were also analyzed. Although the primary area of interest was within the natatorium, wind distribution external to the building was an important factor to capture natural ventilation through doors and roof vents.



Geometry imported from 3D Studio into PHOENICS/FLAIR

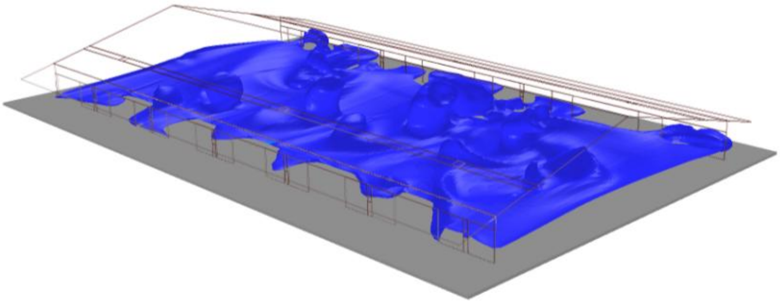
A 3D-Studio engineering CAD file was imported into PHOENICS/FLAIR via the inbuilt AC3D utility, and the major features of the natatorium were included in the model.

Each building component (eg walls, roof, beams etc) was separated into different geometry files to enable their material properties to be prescribed.

A number of open doors allowed natural ventilation into the building, together with gravity ventilation hoods on the roof modelled using a static pressure drop based on manufacturer's specifications. A system of exhaust vents was connected to a duct below the roof apex, driven by two fans provided mechanical ventilation. One of the scenarios considered included additional exhaust and inlet ventilation fans on the two main walls.

The calculation domain was extended far enough away from the natatorium building that pressure disturbances were not too close to fixed pressure boundaries. PHOENICS' "WIND" object was used automatically to set up wind profiles at upstream boundaries (specifying a wind speed/direction at a reference height and the power law to vary speed with height) and fixed pressure conditions at the sky and downstream boundaries.

Thermal material properties for walls and roof were specified, together with typical heat transfer coefficients. Incident solar radiation levels were prescribed on roof and walls taking into account reflection, absorption and radiation losses.



Iso-surface of water vapour over swimming pool

Water evaporation from the swimming pool was calculated from a standard ASHRAE correlation based on experimental data. The correlation considered local air velocity over the water surface, saturation vapour pressures at the water temperature and air dew point, and the latent heat of water at the pool temperature.

The calculated mass of water evaporated from the pool was solved as the CFD calculation progressed, and was dependent on the predicted air conditions local to the pool. The mass of water was added as a source term to the cells next to the pool surface.

The calculation mesh had a total of 7 million grid points, with the majority in the region containing the natatorium. This provided sufficient refinement to resolve the geometry adequately and capture flow detail within the natatorium. The modified K-ε model of Chen and Kim was used to represent turbulence.

Both simulations were used successfully to assess whether natural and/or mechanical ventilation were feasible for best- and worst-case wind scenarios. Predicted temperatures, humidity levels and thermal comfort parameters were checked against target levels. The detailed predicted-air-flow patterns were analysed and used to redesign the position of exhaust and intake ducts to provide better comfort conditions.

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