CHAM Limited
Pioneering CFD Software for Education & Industry

CHAM Case Study – Building HVAC

PHOENICS-3.6.2 [2006] applied to Steady-state Simulations of the Internal Flow within a Multi-storey Building

Introduction

CHAM's Consultancy Team used PHOENICS/FLAIR for the analysis of a multi-storey building in the Kista region of Stockholm, Sweden. A model was created for testing the internal temperature distribution when subjected to worst-case winter and summer condition (i.e. very cold or very hot).

In particular, the customer was concerned about the production of cold downdrafts in the building's atrium or at along the large glassed façades during the winter, and similarly, whether there were regions of unacceptably high air temperature during the summer time.

The building design was supplied to CHAM in the form of a number of AutoCAD.DWG (Drawing) files of the building and its location, along with the operational boundary data, such as the glass specification, the building material, and internal heat sources, together with an estimate of the number of people, and supplementary heating and cooling baffles.

The geometry was created using PHOENICS VR-Editor (Virtual-Reality Graphical User Interface) based on the AutoCAD drawings as shown in the picture below.

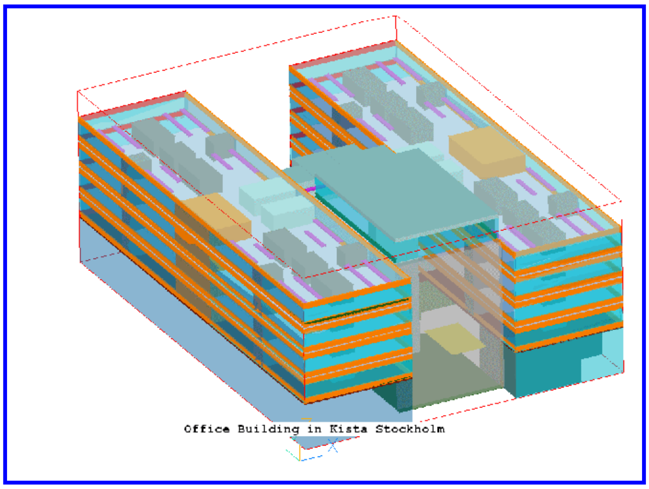

Figure 1: The geometry created within the PHOENICS-VR Editor

Problem Description

Eight offices are located on four floors on either side of the atrium. Included within the model are some 650 objects representing doors, walls, roof, ceilings, glass windows, computers, persons, office furniture and various types of heat-sources. As may be seen from Figure 1, the distribution of these objects in all offices on each floor is similar. Hence, 'Copying' and 'arraying' objects taken from the database available in the VR-Editor made the geometry creation both easy and fast.

To represent summertime conditions, a total solar heat gain of 46,580 Watt is specified through the glass doors and windows, with the radiation projected onto the floors and internal walls. This is in addition to the normal heat generated by people in the conference room and offices, and by lights and machines inside the building. The temperature within the building is regulated by an air conditioning system introducing cooled air at 15°C, and a ventilation system generating a total air exchange of 2300 l/s throughout the building.

The winter case differs in that there is no solar heat affecting the temperature in the building; due to the low temperature outside, the glass door and all the glass windows take heat away from the building. The temperature of the ventilation air in the building is increased from 15°C to 18°C.

Results

The total mesh size of 1.1M cells was used, non-uniformly distributed over the entire calculation domain. A converged solution was obtained after 2000 iterations, which took 22 hours to complete running the calculation on a 3MHz PC, and 8.5 hours on an equivalent 4-processor cluster using the parallel version of PHOENICS.

Figure 2 shows the temperature distribution in the atrium during the summer. As may be seen, the temperature in most areas is around 22°C, which is similarly shown in Figure 3 by the 22.4°C iso-surface.

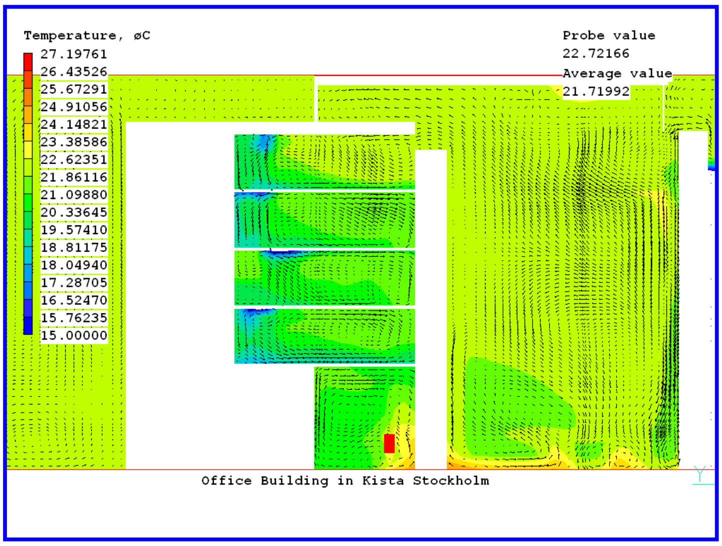

Figure 2. The temperature contours superimposed by velocity vectors at the vertical section in the middle of the atrium (Summer case).

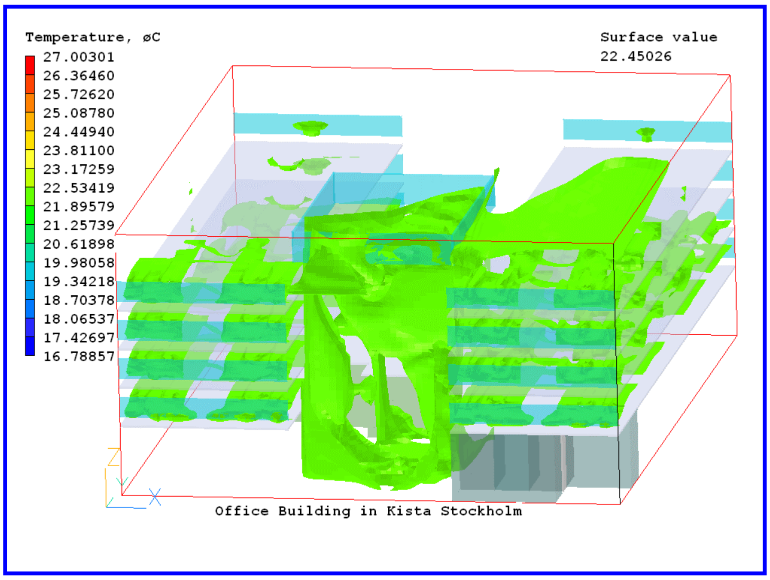

Figure 3. The iso-surface of temperature at 22.4°C degree (Summer case)

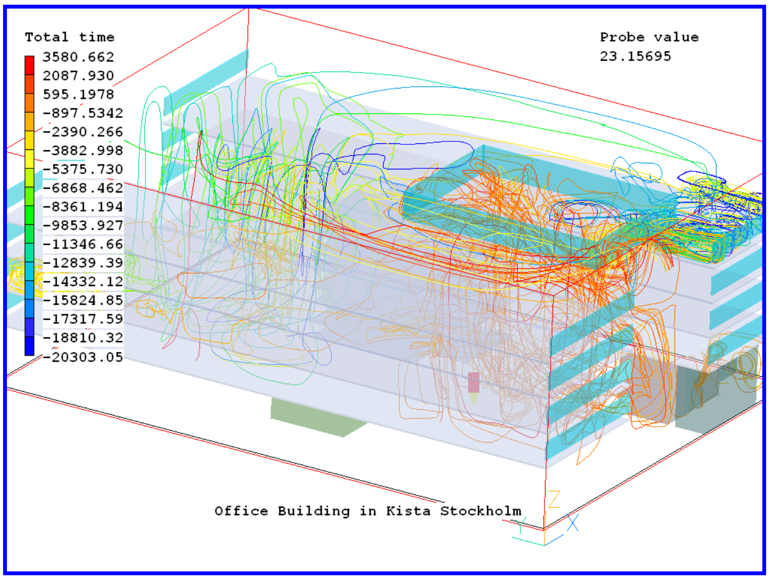

Figure 4. Streamlines starting from the middle of the floor of the atrium (Summer case)

Conclusion

These, and more-detailed, results were supplied to support evidence from CHAM's customer to demonstrate the effectiveness of the building's HVAC design under atypical weather scenarios.

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