CHAM

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Natural Ventilation Modelling of an Apartment With PHOENICS FLAIR

PHOENICS Case Study - HVAC

Introduction

This Case Study describes how the PHOENICS environmental flow solver FLAIR can be used to model natural ventilation inside a building. FLAIR allows the "mean age of air" to be modelled which is particularly useful when identifying areas of poor ventilation. In this particular case the air flow is driven by a pressure difference between opposite faces of the apartment, as commonly might be seen in a high-rise building with open windows. This case served as a demonstration of the capabilities of FLAIR for an application defined by CHAM agents, Shanghai Feiyi, and used for training purposes.

CFD Model and Setup

Figure 1 shows an apartment with several open windows in its external walls. The geometry consists of two CAD files; one describing the exterior shape of the apartment and the other its internal geometry. Windows are specified using "ANGLED-OUT" objects where external pressure is defined. Windows in the south- and east-facing walls have a higher relative pressure which is intended to drive air through the building to exit through the north-facing windows.

A hybrid differencing scheme is used to solve for all variables; it varies between a first-order upwind or central differencing scheme depending on cell Peclet number. The Chen-Kim modified k-epsilon model is employed to simulate turbulence.

Mean age of air is calculated by solving for a passive scalar with a source term of $1s^{-1}$.

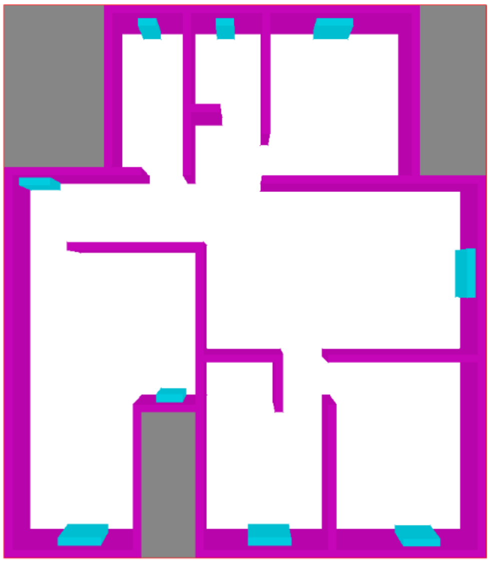

Figure 1 Geometry of Apartment

Specifications

- Domain : 11.6*m* x 13.3*m* x 3.0*m*
- Relative pressure at south and east windows: 5*Pa*
- Relative pressure at north windows: 0*Pa*

Mesh

For demonstration purposes the domain has been discretised using a uniform 60 x 60 x 30 Cartesian grid. This gives a uniform grid with cells of size 0.19*m* x 0.22*m* x 0.1*m*.

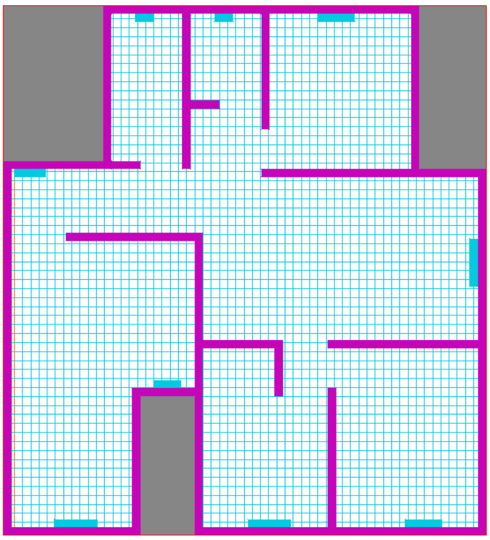

Figure 2 60 x 60 x 30 Cartesian mesh

Results

Figure 3 shows pressure contours through the individual rooms of the building, at a height of 1.45*m* above the floor. The specified 5Pa over-pressure is applied on the external side of the south-facing and east-facing windows.

The pressure level in the rooms adjacent to these windows depends on the balances of the upstream and downstream resistances for each room.

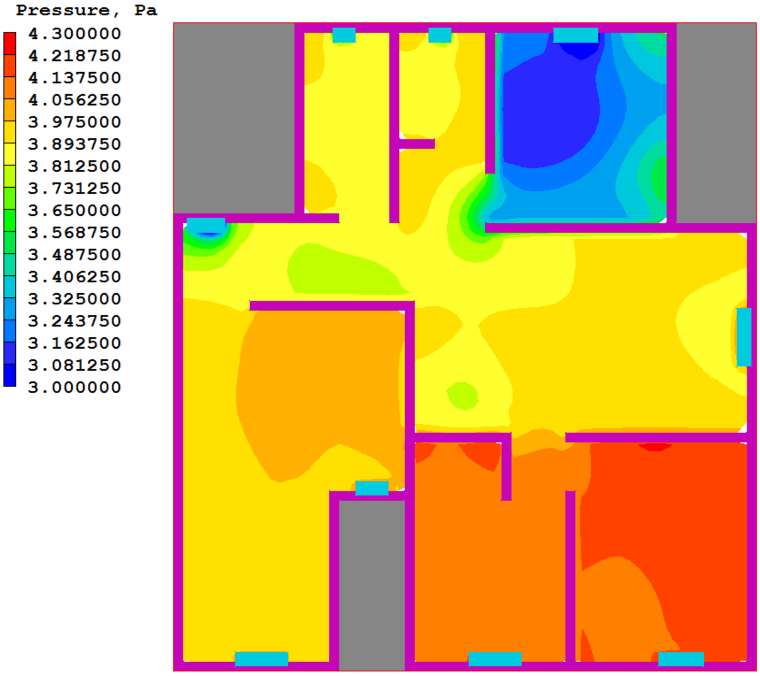

Figure 3 Pressure contours at z=1.45m

Error! Reference source not found. shows the ventilation pattern, at a height of 1.45*m* above the floor. Dark blue areas represent relatively poorly-ventilated corners.

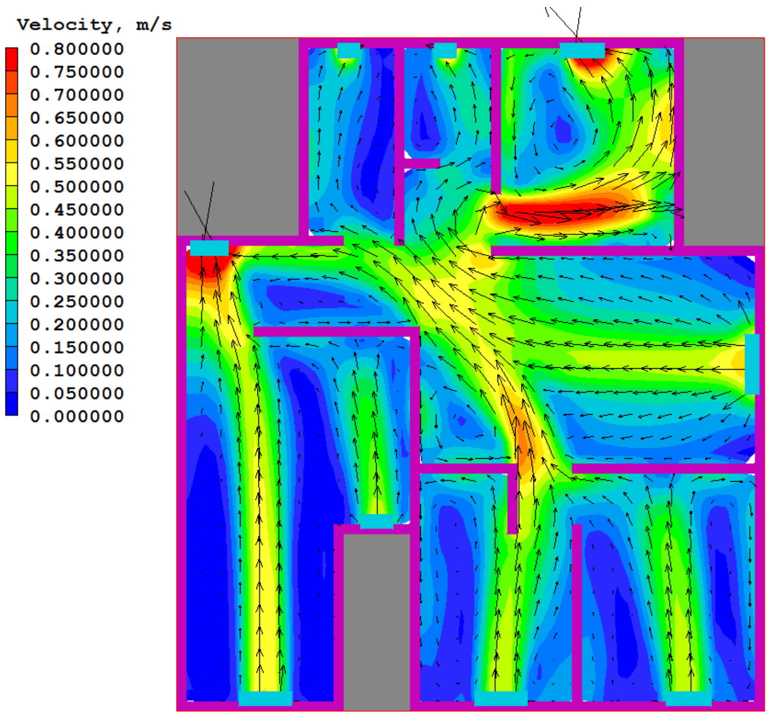

Figure 4 Velocity contours and vectors at z=1.45m

Figure 5 shows the distribution of mean age of air, at the same height. The mean age increases as the air travels through the building, as expected. The highest values of mean age of air are in corners where the ventilation is relatively poor.

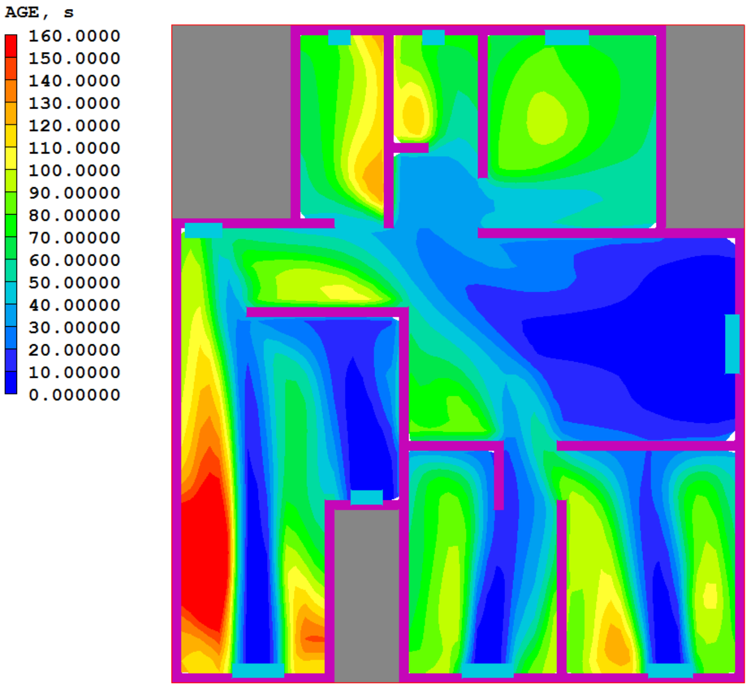

Figure 5 Mean Age of Air contours at z=1.45m

Figure 6 shows the mean number of Air Changes per Hour, again at a height of 1.45*m* above the floor. The highest numbers of air changes per hour occur where fresh air is constantly supplied and the lowest numbers are in poorly ventilated areas where the mean age of air is highest.

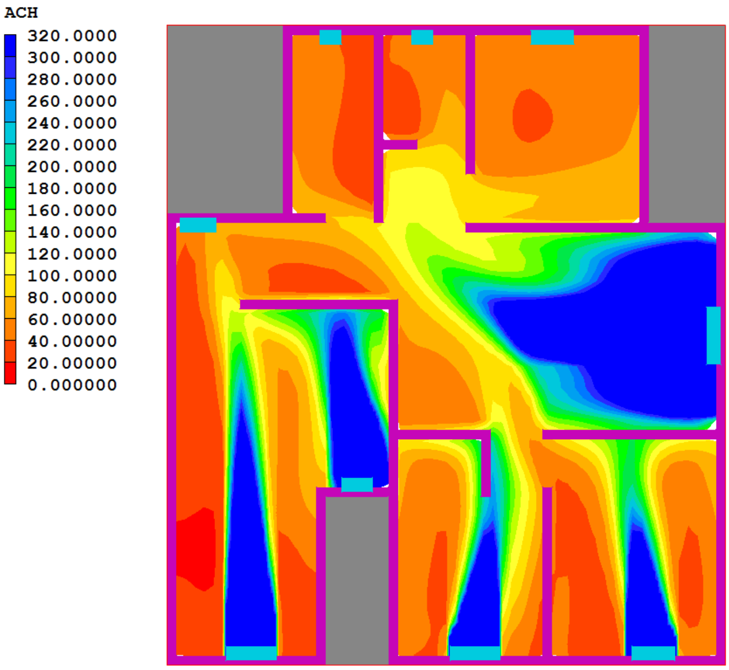

Figure 6 Air Changes per Hour contours at z=1.45m

Observations

This example demonstrates how PHOENICS FLAIR can simulate natural ventilation in an apartment. Pressure difference causes air to flow from south-and east-facing windows towards those in the north wall.

Age of air and Air Changes per Hour are recorded in order to show the quality of ventilation across the apartment and showed that areas with poor circulation can occur when the internal design does not facilitate easy air paths throughout. Inattention to areas such as these can cause problems for ventilation and is an example of how calculation of these variables can highlight potential design deficiencies.

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