PHOENICS Case Study: Fire
Fire in a Gymnasium

Introduction

When designing a building, fire safety is of particular importance. Computer modelling, with its ability to predict flows, temperature and build-up of smoke, plays an important role in fire safety engineering. A model representing a "typical case" was created to demonstrate the capabilities of PHOENICS FLAIR to BR Tech Engineering.

Problem Definition

Geometry was created to represent a basketball court in a gymnasium, complete with a sloping roof and a tiered seating area; dimensions were taken from an engineering drawing provided by BR Tech Engineering. Windows on one side of the building were modelled as inlets to simulate open windows with a constant breeze of 2.5 m/s. The windows opposite were modelled as openings to simulate open windows with no breeze entering. Two openings were modelled at each end of the seating area to represent open fire doors.

A 1.5 MW "t squared" fire, growing at a fast rate, was simulated at an arbitrarily chosen location within the seating area. The fire was modelled to begin at t=0s and to be active for the entirety of the time period analysed.

The case was modelled as transient to model the growth of the fire, build-up of smoke and increase in temperature of the room over a period of 5 minutes. The time period was split into 150 two second intervals; 30 iterations were performed at each interval. The complete solution took a total of 4 hours to compute.

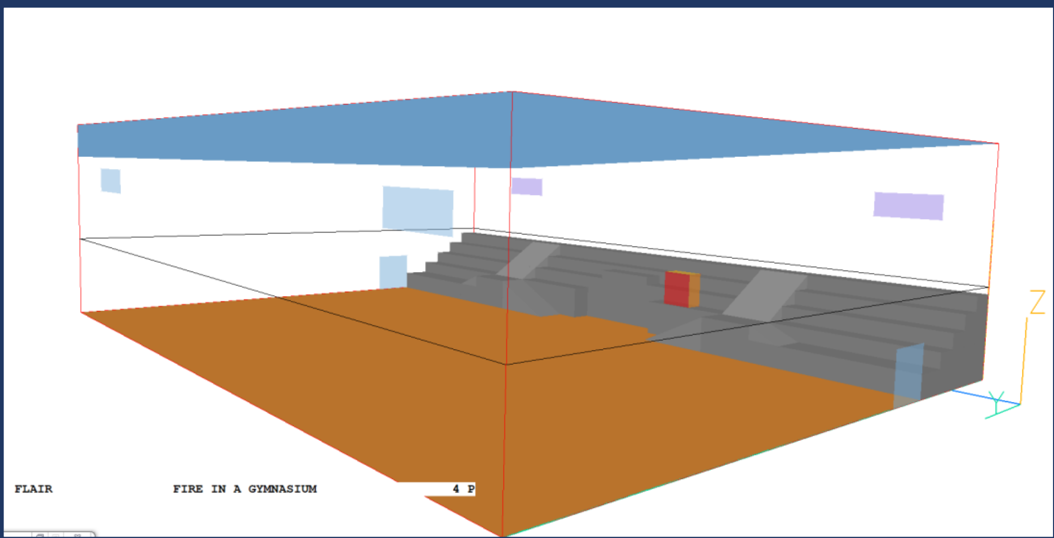

Figure 1 - Basketball court geometry. Fire represented as orange box.

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Results

Figure 2 shows temperature contours across the floor of the seated area after a period of 5 minutes. The temperature in the region which people are seated does not rise above approximately 45°C approximately and is, in fact, significantly lower across most parts of that area. Higher up, however, in a region in which smoke builds, temperatures reach in excess of 76°C. There is no significant change in the temperature at the floor.

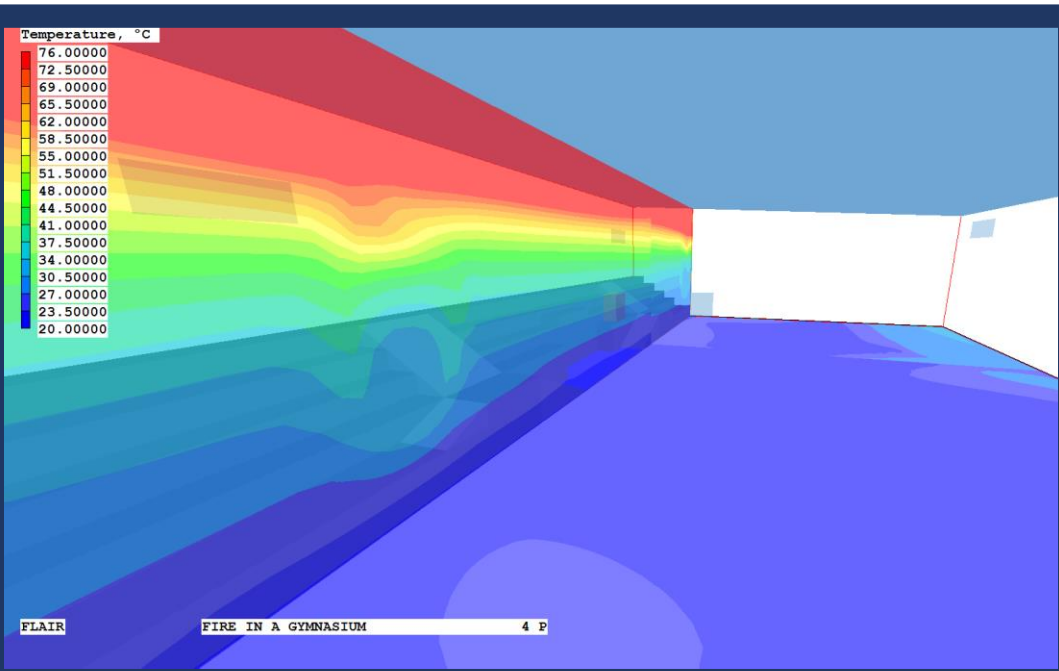

Figure 2 - Contours of temperature

Figure 3 shows 8 velocity streamlines originating from points located at equal intervals on a circle located above the fire; these streamlines were plotted after five minutes. It can be seen that flow rises above the fire and, due to convection, flows along the ceiling. Some of the flow leaves the domain via an open window; this suggests smoke would leave the room via this window.

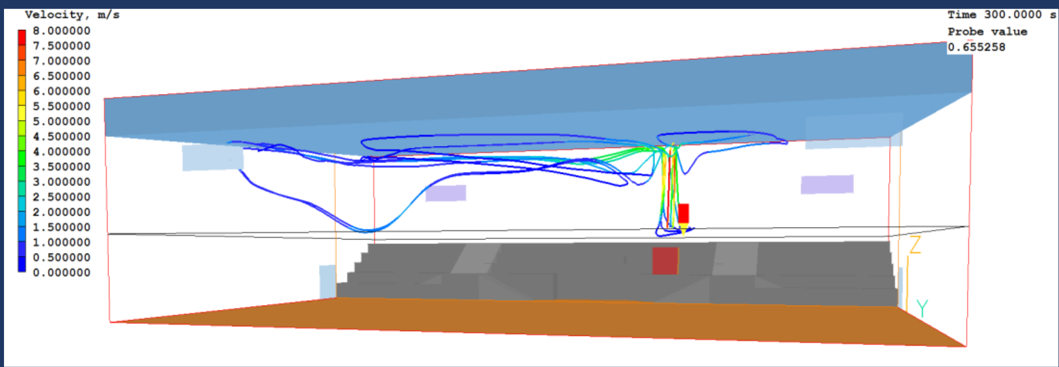

Figure 3 - Velocity streamlines originating from 8 locations in a circle above the fire.

Figure 4 shows an iso-surface of visibility (set to 2.5m) for light emitting objects after 5 minutes; this parameter is directly related to the build-up of smoke. Having analysed this parameter at each time step it could be seen that smoke build-up increases with time; this suggests that open windows and doors alone do not provide adequate ventilation in case of a fire.

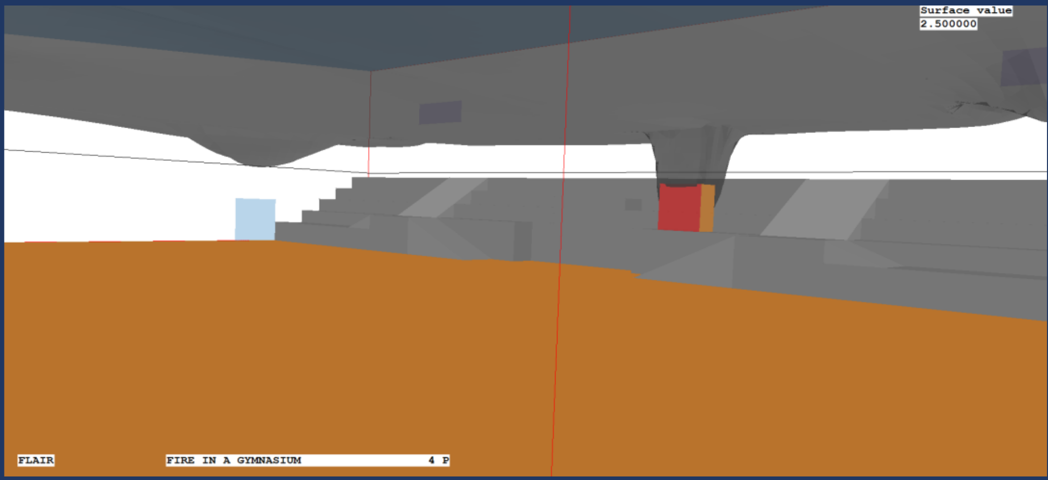

Figure 4 - Iso-surface of visibility for light emitting objects.

Conclusion

The CFD analysis showed that, although temperatures do not reach dangerous levels in the seated area, there is a significant build-up of smoke which could be reduced by increasing ventilation in the room. Increased ventilation be achieved through the addition of extractor fans and the revised situation modelled, using PHOENICS, and compared with the original simulation.