

Introduction

Fires in closed shopping-malls that are attended daily by a big number of visitors can cause many fatalities among panicked people running and pushing to get out of the on-fire mall. Due to the large volume of malls and the complexity of their structure, it is difficult to predict the smoke movement in case of fire. Thus, evacuation plans cannot be set easily.

The objective of this report is to investigate, using ANSYS Fluent software, the effectiveness of the smoke extraction system of the Meraas Outlet Village mall under a fire scenario. This shopping-mall has an approximate surface of 6.600,00 m² and it is located in Dubai (UAE).

This project was carried out by students under the supervision of Fluid Codes technical team as part of an internship.

Computational aspects

- **Numerical model:** The flow is assumed to be incompressible using the hypothesis of Boussinesq, to take into account the buoyancy effects. The standard k-ε turbulence model was used in the analysis.
- **Computational mesh:** hybrid mesh of tetrahedrons and hexahedrons with 8.1 million of cells
- **Fire modelling:** The fire has been modelled as a heat source and a smoke source generated as a combustion product. We have simulated a fire area of 20 m² (average area of a shopping center kitchen), which corresponds to a typical fire power of 5 MW (Fig. 1).

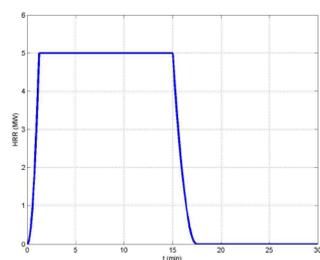


Figure 1. Power curve (heat release rate in MW)

Simulation Domain & Results



Figure 2. Three-dimensional view of the main body of the shopping mall.

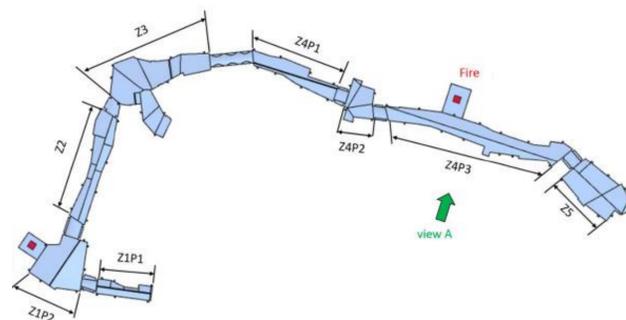


Figure 4. Top view of the main body of the mall and fire location

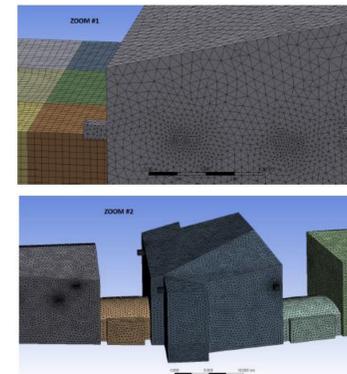


Figure 3. Details of the mesh with 8.1 million of cells, corresponding to the regions marked in Fig 2

Zones	Flow rates (m ³ /min)
Zone 1 part 1	479
Zone 1 part 2	1158
Zone 2	1260
Zone 3	2310
Zone 4 P1	756
Zone 4 P2	414
Zone 4 P3	1590
Zone 5	1290

Table 1. Partial flow rates into the different zones shown in Fig 4.

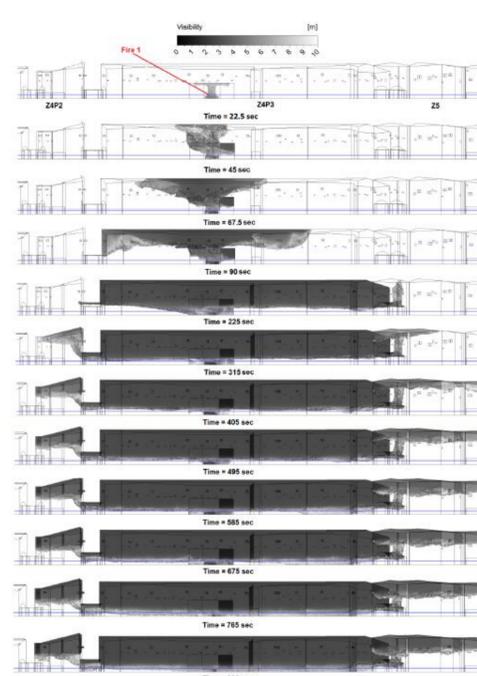


Figure 5. Side view snapshots of the smoke propagation during the growth period ($0 < t < 75$ sec) and maximum power period ($75 \text{ sec} < t < 900$ sec). The visibility through the smoke is measured in meters. View A in Fig 4.

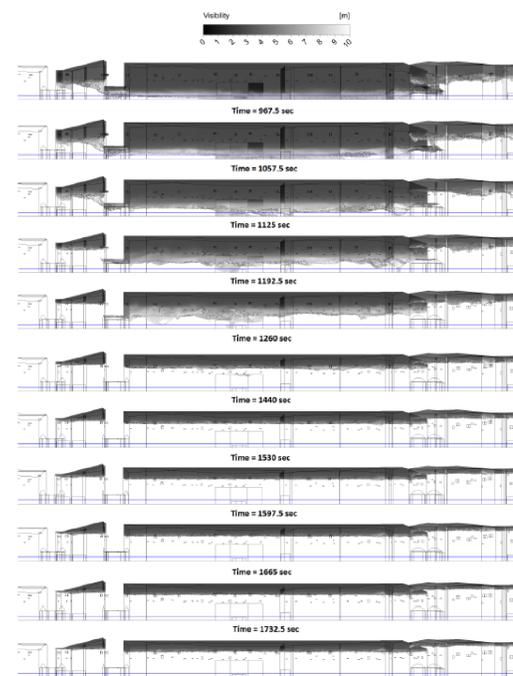


Figure 6. Side view snapshots of the smoke propagation during the decay period ($900 < t < 1050$ sec) and fire off period ($1050 \text{ sec} < t < 1800$ sec). View A in Fig 4.

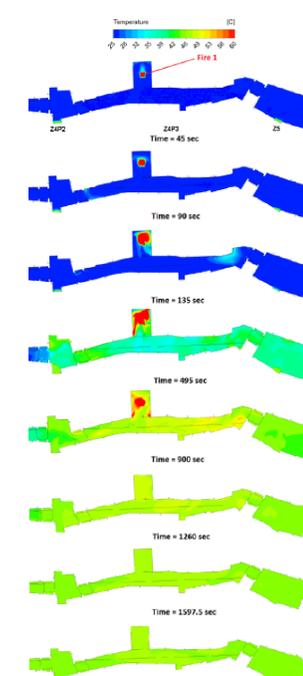


Figure 7. Top view snapshots of temperature at 1.5 meters height.

Conclusions

- At **225 seconds** of the fire start, the smoke fills **more than 75%** of the corridor Z4P3 and it is spreading to atria Z4P2 and Z5.
- After **495 seconds** of the fire start, the smoke layer reaches the average breathing height of **1.5 m** in corridor Z4P3.
- The **most dangerous moment** in this fire scenario is reached at **900 seconds**, when the fire starts to decrease. The smoke fills completely the corridor Z4P3, and the atria Z4P2 and Z5 are filled to half height. However, the extraction system avoids that the smoke reaches other parts of the mall.
- After the fire is totally off (at 1050 sec), the extraction system needs **less than 2.5 minutes** to clear completely the breathing height, and **8 minutes** to evacuate the smoke until the extraction height.
- The **average temperature** outside the kitchen is always **under 55 °C**, i.e., 10 °C more than the temperature outside the mall (45 °C).

References

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