Case Study

Jesmond ENGINEERING

Pollution Control & Smoke Clearance in an Underground Carpark

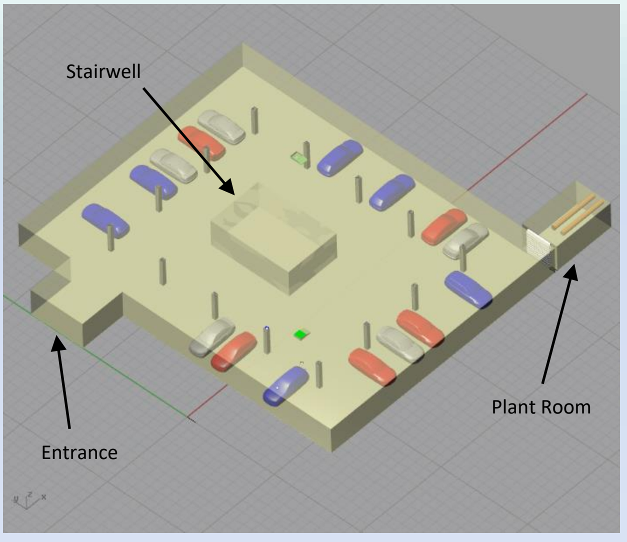

Figure 1 *The underground Car Park with entrance, stairwell and plant room marked.*

Task Objectives

Jesmond Engineering was contacted for an engineering assessment of the proposed ventilation in an underground car park. The CAD model for the car park is shown in Figure 1 with the entrance, stairwell and plant room marked. Computational Fluid Dynamics (CFD) was used to ascertain whether the proposed car park design was capable of meeting the ventilation requirements specified in building regulations for pollution and smoke control. The car park design proposal was for a mechanical ventilation system that included two impulse fans in the parking area and two extract fans located in a plant room. Two scenarios were analysed which were pollution (CO) control and smoke control. In the pollution scenario the impulse fans and only one of the extract fans operated at 50% of their maximum performance. During smoke clearance both impulse and both extract fans operated at 100% of their maximum performance Jesmond Engineering constructed a CFD Model which could solve the airflow around the car park in both scenarios with the aim of either confirming the acceptability of the design or allowing further design changes to be examined.

Pollution Control

According to regulation, the mechanical ventilation system should achieve a rate of 6 Air Changes per Hour (ACH) around all areas of the car park and 10 ACH where car engines are running and queues can form. Extract fans should be arranged to prevent stagnated areas where stale air can accumulate.

Smoke Clearance

During smoke clearance the ventilation system should achieve 10 ACH in the area where the fire is located. Also air velocities along escape routes should not exceed 5m/s to avoid impeding occupants escaping and furthermore, pressures on doors should ideally be negative and low.

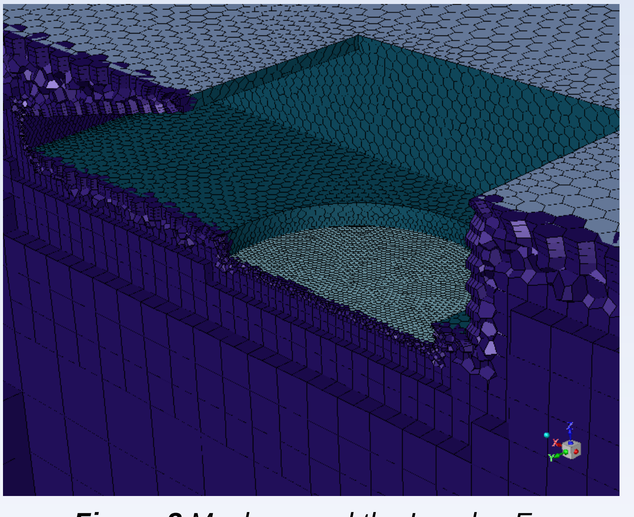

Figure 2 *Mesh around the Impulse Fan*

Computational Fluid Dynamics

A CAD model was constructed, as illustrated in Figure 1. The model contained all the major features of the carpark design including pillars and vehicles to ensure that it was representative of the actual design. The impulse fans were installed below the ceiling and the extract fans were contained in a plant room that was separated from the main car park by a louvre panel. Figure 2 shows an example of the mesh around the ceiling mounted impulse fan.

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The software used for this project was the ANSYS Fluent commercial CFD system. The geometry was meshed with a 3D Poly-Hexcore Mesh down to a size of 0.005m on the boundary surfaces. This mesh technology contains fewer cells than older approaches but has more degrees of freedom in the mesh allowing for faster and more accurate solutions. The simulation was run using a RANS solver using the K-Omega SST model.

The CFD analysis allowed both the airflow and the age of air to be examined at various levels in the car park. The number of air changes per hour could also be examined. The boundary conditions could be modified if required for changes such as whether the car park entrance was open or closed. The impulse fans could be relocated if the results did not meet the building regulation requirements.

Simulation Results

Simulations were conducted for both Pollution Control and Smoke Clearance and a snapshot of the results from both scenarios are shown below. The differences can be seen in the velocity contours for the two scenarios where the fans operate differently. It can be seen that the velocity of the air at the car park entrance and the stairwell escape route is less than 5 m/s during Smoke Clearance. It was also possible to demonstrate that air pressures on escape doors were all negative and did not exceed requirements during the Smoke Clearance scenario.

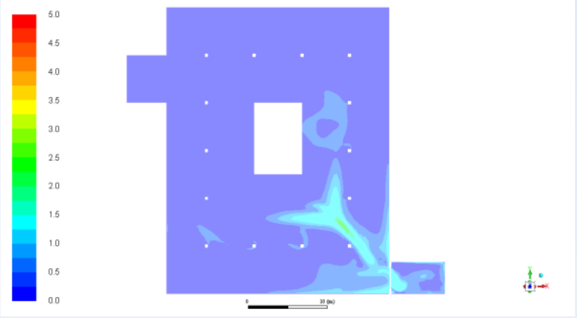

Figure 4 *Velocity Magnitude (m/s) at 1.8m above FFL during Pollution Control*

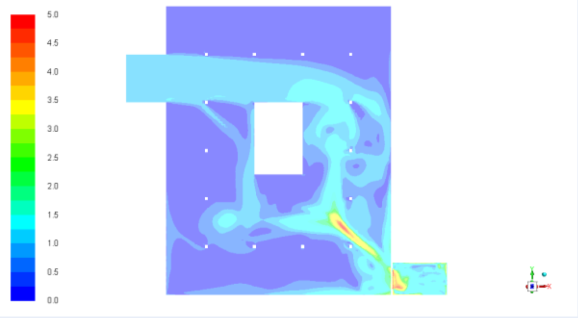

Figure 5 *Velocity Magnitude (m/s) at 1.8 above FFL during Smoke Clearance*

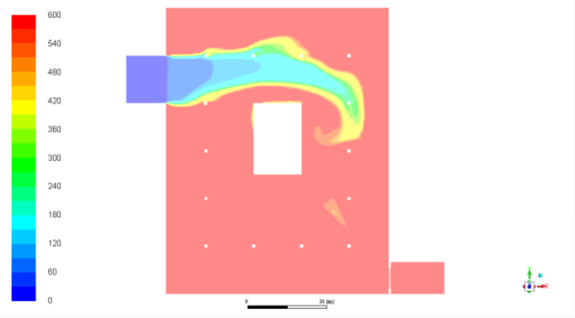

Figure 6 *Mean Age of Air (s) at 1.8m above FFL during Pollution Control*

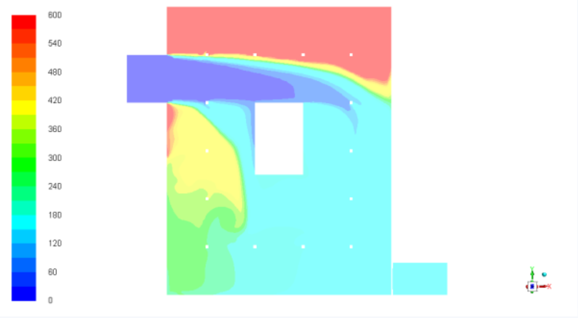

Figure 7 *Mean Age of Air (s) at 1.8m above FFL during Smoke Clearance*

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