Case Study

RENUDA
FLUID SOLUTIONS

Smoke recirculation in tunnels for different wind conditions: BG Consulting Engineers

The Background

BG Consulting Engineers is an international firm focused on infrastructure, environment, building and energy. They recorded a turnover of €83 billion in 2014 and employ more than 650 people. With internationally recognised expertise in tunnel technologies, BG were part of a consortium involved in the design of a highway system around the Greek city of Patras which includes a series of tunnel pairs across three hills. For each hill, two parallel and separate tunnels are used to accommodate the traffic in each direction. As the two tunnels are in close proximity, there is a risk that smoke emanating from an accidental fire in one of the tunnels could be reingested in the other tunnel upon exiting, depending on external wind conditions and tunnel ventilation settings. As part of the consortium, BG was commissioned to examine the risk of recirculation in three tunnel pairs and propose preventative measures.

"Renuda's consultants are competent, efficient and cost-effective. They delivered a successful project on time and within budget."

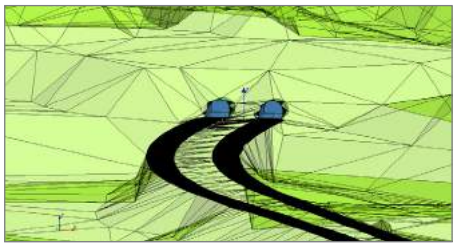
Xavier Guigas

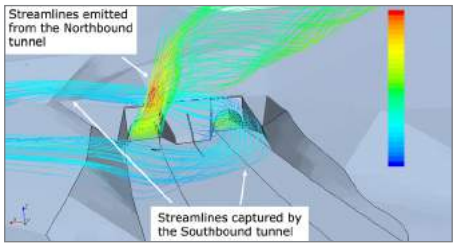
Expert Engineer, BG

The Challenge

To evaluate the amount of smoke recirculation for different wind conditions for three different tunnels, each with its own hill topology, smoke emission speed and fire temperature. An added challenge was to evaluate the efficiency of different shapes of external walls, a system envisaged by BG to maximise safety by shielding tunnels from each other and provide a static solution rather than a dynamic one, such as installing fans.

An added challenge was to reconstruct the tunnels and viaducts, which were all missing from the topological data files available.

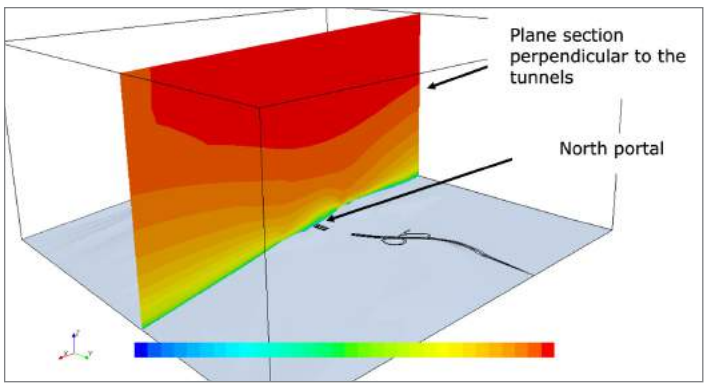




The Solution

Using STAR-CCM+, large scale 3D simulations for each hill and wind scenario were performed with careful modelling of atmospheric wind profiles, hill and infrastructure topologies (tunnels, highway lanes and bridges) and the envisaged external partition wall designs for the hills which were considered most sensitive to reingestion. With these models the flow of smoke emanating from the tunnel fires could be modelled taking into account interaction with the wind and the tunnel's ventilation settings, and the amount of smoke potentially reingested in the sister tunnel could be quantified.

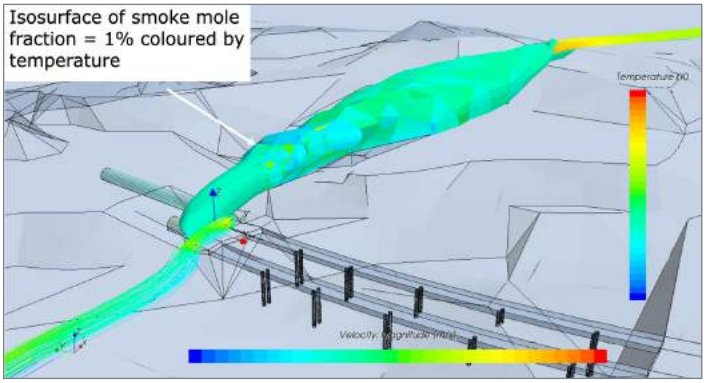
Before any simulation work could commence, a significant amount of cleaning and preparation first had to be performed to recreate the topology of the local terrain and add the missing tunnels and viaducts. These features were recreated partly based on Google Earth information, and topology files, photographs and blueprints supplied by BG. The external wall designs identified by BG to prevent smoke recirculation between tunnel pairs were then built into the models based on the shape, dimensions and position given by BG, resulting in three scenarios; without a separating wall between the



tunnels, with a full separating wall, and with a partial separating wall.

Once the reconstruction was complete, simulations were performed for each hill to determine the tunnel smoke reingestion that might result from an accidental fire, using smoke outflow, healthy tunnel ventilation inflow, wind directions and wind strengths identified by BG from local wind data and its own fire calculations.

In order to capture the smoke interaction with the wind and the tunnels close to each portal accurately, particular care was taken with recreating realistic atmospheric (wind) conditions, accounting for the Atmospheric Boundary Layer and the shape of the terrain, and carrying out simulations over areas as large as 9 to 24km^2.

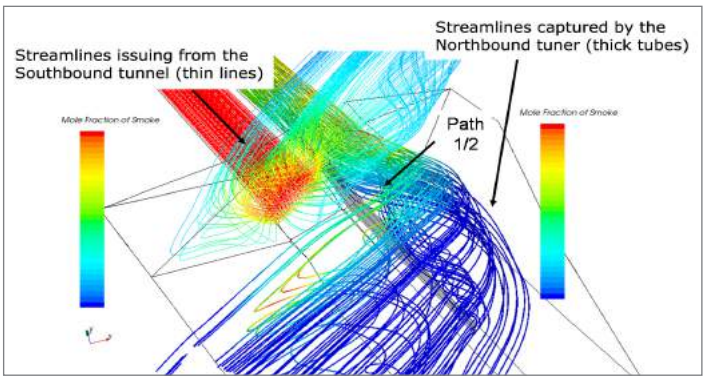


"We appreciated very much the way Renuda reported on progress throughout – it was very comfortable for us"

The three-dimensional turbulent dispersion of smoke, including heat transfer and buoyancy, was simulated for a total of 10 different cases. For each case a number of calculations were performed to refine the meshes, adjust the models (for example by extruding the tunnels) and find the most suitable numerical parameters.

The Result

- Renuda's CFD simulations made it possible to gain qualitative and quantitative information on the smoke dispersion including its interaction with the atmospheric wind, the terrain, the separating walls, and the two tunnels for each portal.
- Based on the information provided, Renuda found that, for all the cases studied, the additional full wall design proposed by BG to prevent smoke transfer between the tunnels provided a significant reduction in smoke ingestion.



How BG Benefited

The research conducted by Renuda was part of a larger project BG was involved with the city of Patras' highway network. BG and their client were impressed by the simulation work produced by Renuda and the insight it gave them into the smoke recirculation for the three tunnels.

Why did BG choose Renuda?

- Of the four companies competing for the project Renuda were the most suitable.
- BG was impressed with Renuda's versatility and approach to problem solving and believed they were consultants they could work well with.
- They were reassured with the quality of the work and results of previous projects undertaken by Renuda.

"Renuda's work is good – we will use them again and willingly recommend them"

Xavier Guigas

Expert Engineer

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