Reaping the benefits of tunnel fire suppression

The 625m long Nordhavnsvejens Tunnel in Copenhagen has become the latest European tunnel to be constructed with a fixed fire suppression system. The tunnel is located in a busy urban area, with the ever-present risk of congestion, especially during rush hours. In the absence of a fire suppression system, motorists downstream of a fire could be exposed to dangerous concentrations of smoke. The suppression system can reduce the peak fire size by around 60%, and can cool the smoke to the extent that it no longer poses an immediate threat to life.

International standard-setting organisation including the National Fire Protection Association and the World Road Association (PIARC) have modified their hitherto dismissive advice with regards to tunnel fire suppression systems. Their updated standards state that such systems can indeed provide valuable benefits in terms of life safety, asset protection and road network integrity. However, that does not mean that all road tunnels must be fitted with fire suppression systems - their installation and maintenance must mitigate a genuine risk in a cost-effective manner.

The cost-effectiveness of tunnel fire suppression systems can be improved by a process of "compensation" – which means that the cost of other systems installed in a tunnel can be reduced, which lowers the overall installation costs whilst still maintaining an adequate level of safety. An example of such a "compensation" process was the redesign of the ventilation system for a 4km tunnel in Turkey.

We were instructed by the Danish manufacturer VID Fire-Kill ApS to calculate the required ventilation capacity in a planned new Turkish road tunnel, with and without their TUNPROTEC fire suppression system. This is a low-pressure system that has been tested at the Runehamar Test Tunnel in Norway, for potential fire sizes of up to 100 MW.

The effect of the fire suppression system on the fire heat release rate was ascertained through experimental measurements which suggest a reduction from 100 MW to 40 MW, with 50% of the suppressed fire heat release rate being convectively transported. The reduction in fire size of an actual incident will be a function of many parameters, including the reliability and speed of fire detection, the origin and type of fire (e.g. shielded or unshielded), the water density rate, droplet size distribution and ventilation operation. There is also a probability that the activation of the fire suppression system may be delayed, or that it could fail to operate entirely.

In the north tunnel bore with a downhill gradient of up to 3.4%, the total number of jetfans to be installed can be reduced from the 34 fans currently proposed for the unsuppressed system. Up to 12 operating fans are required to generate the critical velocity for smoke control with the fire suppression system activated. In addition, 4 jetfans are required to account for maintenance and fire damage. This give a total of 16 to be installed.

In the south tunnel bore with an uphill gradient of up to 3.4%, the total number of jetfans to be installed can be reduced from the 26 fans currently proposed for the unsuppressed system. Up to 8 operating fans are required to control the smoke with the fire suppression system activated. In addition, 4 jetfans are required to account for maintenance and fire damage. This gives a total of 12 to be installed. The total number of installed jetfans in the two tunnel bores can therefore be halved. A reduction in installed real power of approximately 2 MW was estimated for the revised ventilation system with fire suppression.

Other potential “compensation” processes include a reduction in passive fire protection, and longer distances between tunnel cross-passages and shafts. More research in this area would be of great benefit to tunnel designers, owners and operators.

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