A popular science summary of a master thesis, Division of Fire Safety and Engineering, Faculty of Engineering, Lund University.

Are the tools used for calculating safety in road tunnels reliable?

- *The verification and validation of a probabilistic risk analysis method for road tunnels*

Many countries and people depend on road tunnels for effective transportation. A set of tragic accidents in Europe around the year 2000, for example, the Mont Blanc tunnel fire in 1999 where 39 people were killed, lead to the increased awareness of the potential dangers of road tunnels. Following these events, there was a large pressure to make road tunnels safer and risk analyses of road tunnels became frequent after *Directive 2004/54/EC* was released by the European parliament. A number of tools and approaches has since then sprung up to meet this demand for risk analyses, one such tool is ARTU by Cantene®. This work has been done to validate and verify its reliability.

Even though fewer accidents happen in tunnels than on open roads, the possible consequences are higher because of the confined space. This leads to the accumulation of toxic gases and heat which are dangerous for people that are evacuating.

The size of a fire and how dangerous it is to people can vary greatly depending on a number of factors. Is it a small car or a large tanker carrying gasoline that is burning? How many people are there in the tunnel and do they understand the danger and that they need to leave? There are many questions to be asked when one is to analyse the safety of a specific tunnel. A risk analysis tool such as ARTU aims at taking the most relevant aspects affecting the fire safety into account to calculate the risk level of the tunnel, often expressed as the probability of a certain number of fatalities caused by fire per year. This number, in turn is compared to a national maximum set value for risk.

For a risk analysis tool to be trustworthy, it needs to be proven to represent reality in a good way and it needs to make calculations without any mistakes, these steps are called validation and verification. Validation of ARTU has been conducted by the comparison of fire experiments in road tunnels and an identical set-up in the tool. This comparison shows how closely ARTU can simulate real fires. A further comparison was made with a well-established 3D fire simulation tool called FDS to compare variables that were not included in the experiments. The calculations that the tool makes when it comes to evacuation, e.g. how fast people walk, was checked by comparison with hand calculations using the same equations as ARTU. The final output of the tool, the FN-curve which explains the frequency of a specific number of falities per year in a tunnel, has been verified using hand calculation.

The results from the validation and verification show that the fire calculations are conservative in comparison to the experiments. Fire scenarios with mechanical ventilation have higher agreement compared to the experiments than fire scenarios without ventilation, which are more conservative. The evacuation and toxicity assessments show good agreement to hand calculation, as well as the creation of the FN-curve.

There are a large number of uncertainties that might affect the results. Both natural variation and uncertainties which come from incomplete information about certain variables are present when doing risk analysis for road tunnels. These were addressed using statistical distributions instead of set values and a sensitivity analysis was made to find which variables affect the results the most.

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