Above: Dr. Fathi Tarada

# Breath of fresh air

Tunnels often have a bad name for air quality, some deservedly. A new report next year by the World Road Association (WRA), aims to set tunnel air quality standards for a range of airborne pollutants. Dr. Fathi Tarada, co-chairman of the WRA Working Group on Air Quality, Ventilation and Fire, also managing director of Mosen, explains

Tunnel ventilation systems are normally designed to maintain acceptable air quality and visibility levels during normal operation, and to control the spread of smoke in case of fire. While the fire case is often the dominating factor for highway and non-urban tunnels, in tunnels with a high traffic load and frequently congested traffic, the fresh air requirement for normal operation can be dominant. It is therefore important to consider the minimum fresh-air requirement required to ensure adequate in-tunnel air quality and visibility thresholds.

The main changes in the new WRA report comprise the inclusion of new emission data up to the year 2030, including the new emission standards EU5 and EU6. Light-duty vehicles will also be considered. The introduction of tighter emissions standards worldwide has resulted in reductions as new, lower emitting vehicles replace older, higher emitting vehicles. These changes are fully reflected in the new report.

For the first time, WRA will offer two calculation schemes for estimating vehicle emissions for a certain design year. One approach is based on a simple methodology using 2010 as the base year, adjusted with country-specific influencing factors concerning different design years, emission standards, etc. The country-specific factors are particularly useful in developing countries and countries in transition, where emissions data can be sparse. The second allows a detailed emission calculation based on vehicle-specific emission factors. However, this requires a detailed knowledge of the fleet composition for the design year.

## Peak levels

The primary air quality criteria in the WRA report remain carbon monoxide (CO) concentrations and visibility limits, with no major changes proposed for design and threshold (i.e., safety) levels. However, the report recognises the increasing importance of nitrogen dioxide ($NO_2$) as a pollutant in tunnels. Results of studies in which people have been exposed to $NO_2$ have demonstrated that this pollutant can negatively affect healthy as well as sensitive people. For healthy people, effects have been noted for peak levels higher than 4000 µg/m³; no effects have been observed for peak levels below 2000 µg/m3. Based on these findings, WRA proposes an in-tunnel air quality level of 1 ppm $NO_2$ as an average value. For comparison, the short-term (15 minute) occupational hazard limit set for $NO_2$ by the UK Health and Safety Executive in 2002 was 5 ppm.

The new report will offer guidance with respect to estimation of non-exhaust particulate matter emissions due to re-suspension and abrasion, although it recognises that there are large uncertainties in such estimations.

Stopped traffic and vehicle speeds around 10 km per hour typically define the normal ventilation capacity requirements. In longer tunnels, the ventilation equipment may be oversized if congested or stopped traffic is assumed over the entire tunnel length. Therefore, the report advises that it is preferable to prevent congested/stopped traffic over the full tunnel length by a traffic control system.

Many pointers are provided to guide the unwary in designing and operating tunnel ventilation systems. For example, the percentage of heavy goods vehicles in traffic is normally quoted as an average percentage of the total traffic flow. However, this value is normally too high when applied to peak traffic flow, and this may cause an over-dimensioning of the ventilation system.

Although the report focuses on the application of emissions standards, it is widely recognised that no matter how well a tunnel ventilation system is designed, it is important that it is operated properly in order to maintain a reasonable air quality both within the tunnel and also in the immediate vicinity of the portals. This requires reliable in-tunnel air quality measurement, and a responsive control system for the ventilation system.

## System types

The new WRA report does not discuss the merits and drawbacks of alternative ventilation systems, since these have already been covered in previous publications. However, every ventilation system has its limitations, and these can complicate its operation and control during congested periods. For example, semi-transverse ventilation systems such as those employed in older London tunnels including the Rotherhithe Tunnel have 'dead zones' where the longitudinal air velocity is close to zero, and the concentrations of pollutants are therefore high. Longitudinal ventilation systems with jetfans or Saccardo nozzles do not have this drawback, but generally have their highest pollution concentrations at the discharge portal. Fully-transverse ventilation systems can provide a high level of air quality throughout the length of a tunnel, but are by far the most expensive option in terms of construction and operating costs.

Through an improvement in the design, operation and control of tunnel ventilation systems, we can look forward to a day when we can breathe easily while driving through tunnels, and when tunnels finally lose their poor reputation for air quality. The new WRA report may allow us to go one step closer towards that goal.