Dispersion modelling of a 9 km long section of the Budapest ring motorway

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In this paper wind tunnel dispersion tests and accompanying numerical simulations of the planned north section of the Budapest ring motorway M0 are reported. The investigated 5 variants of the motorway run close to populated suburban areas in complex terrain and include several bridges and road tunnels. Responding to the increased public awareness of the project an extensive wind tunnel test was initiated by the National Infrastructural Development Corporation to provide a solid basis for the environmental impact assessment.

The measurements were carried out on a modular, 1:1000 scale model of 28.5m^2 total area, resolving the topography, buildings, vegetation and pollutant sources of the surroundings. The model was divided into 3 junctions to fit into the enlarged test section of the Goettingen-type wind tunnel. The atmospheric boundary layer profile was modelled by a horizontal grid, spikes as well as roughness elements and was checked by CTA measurements.

After preliminary tests of the pressure gradient and Reynolds-number dependency, concentration measurements were performed for each source and each wind direction to determine the contribution of the different sources to the concentration. Road segments were treated as line sources; the pollutants produced in the road tunnels were supposed to leave the road tunnel at the tunnel exit in traffic direction and modelled as point sources with horizontal momentum. Methane was used as tracer gas; samples were collected simultaneously by an automatic sampling system and analyzed by a flame ionization detector afterwards. In total 262 sets of concentration measurements, each consisting of 10 to 22 sampling points were performed.

The wind tunnel tests were accompanied by numerical simulation of the same area using the MISKAM code, which was applied for flow and dispersion simulation over complex terrain for the first time. Although the comparison of wind tunnel and numerical concentrations gave acceptable results, the observed deviations showed that minor details of the model geometry and the different treatment of sources have a large influence on the results.

Full scale concentrations of NO_x, PM_{10} and CO were determined based on the normalized concentrations from the modelling, the real traffic emissions and the background concentration.

The results both from measurement and numerical simulation showed that in case of road sections running on the surface, concentration limits are only exceeded in a narrow strip along the road, as opposed by the more hundred meter long plumes caused by tunnel exits. Upon our recommendation, the tunnel ventilation system design was extended by ventilation stacks which will exhaust polluted tunnel air in 20 to 35m height above ground and thus, avoid large concentrations at ground level.

Figure 1. Part of the model in the wind tunnel

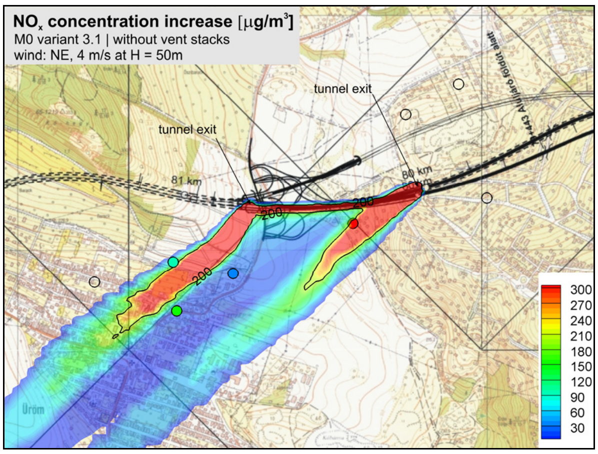

Figure 2. Concentrations from wind tunnel (circles) and numerical simulation (contour plot)