Title:
Transient Analysis of Ventilated Tunnels with Junctions Using Graph Theory
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## ABSTRACT

The conventional analysis, known as the closed loop method, is hand-made for each structure of the tunnel. We presented a method for general-purpose and high-speed numerical analysis of road tunnel ventilation using graph theory. Some reasonable calculated results of a longitudinal and a transverse ventilation tunnel were obtained. We verified the validity of the method through the comparison of calculated and measured results in actual tunnel data.

In graph theory we represent a complex tunnel with a network, where arcs correspond to pipelines, and nodes correspond to their physical interconnection points. We need to establish the nodes-pipes incidence matrix that represents network topography of the pipeline connections, but we do not need to consider the loop relation of wind pressure. We are then able to quite simply handle many types of tunnel structure, including various ventilation forms such as longitudinal, transverse and/or their mixes, and complex tunnel tube structure with several junctions. Next, we classify the tree and co-tree sets of arcs in the complex tunnel tube and achieves high-speed network analysis by solving only equations concerning the wind speed of the co-tree sets. Furthermore, we diminish the number of ranks in the incidence matrix by setting the ventilator as the constant flow source, in order to achieve a higher speed simulator.

Some reasonable calculated results of the wind velocity and the pollutant concentration in short CPU time showed the superiority of the new scheme over the existing algorithm for the wind pressure loop method. In fact, we have quantitatively verified the coincidence of simulation results with measured data on the Shin-Kobe tunnel operated by the Kobe City Road Public Corporation in Japan. Its length is 6.9km and incorporates a mixed ventilation system.

In the future, we expect that this new method will be more widely used in the big cities that have complex tunnels with many junctions. Then we will be able to design the ventilation equipment, not only for normal conditions but also for the case of fire.

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