PHYSICAL SIMULATION OF VEHICULAR POLLUTION DISPERSION IN AN ISOLATED URBAN STREET CANYON UNDER HETEROGENEOUS TRAFFIC CONDITIONS

by

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DEPARTMENT OF APPLIED MECHANICS

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to the

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Dedicated

to

My Parents

CERTIFICATE

This is to certify that the thesis entitled "**Physical Simulation of Vehicular Pollution Dispersion in an Isolated Urban Street Canyon Under Heterogeneous Traffic Conditions**" being submitted by **Mr. Niraj Sharma,** has been prepared under my supervision in conformity with the rules and regulations of the **Indian Institute of Technology, Delhi.** I further certify that the thesis has attained a standard required for the award of a degree of **Doctor of Philosophy** of the institute. This work, or any part thereof, has not been submitted elsewhere for the award of any other degree or diploma.

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ABSTRACT

Air pollution from motor vehicles is one of the most serious and rapidly growing problems in various urban centers of the world. Predicting the distribution of pollutants under various urban conditions such as urban street canyon is extremely complex involving a variety of physical and meteorological factors including vehicle emissions, wake effects, canyon wind flows and turbulent dispersion.

Over the past two decades, significant progress has been made in understanding and modelling vehicular pollution dispersion phenomena under these urban environmental conditions by using Environmental Wind Tunnel (EWT) technique. In the EWT, the emission conditions, different meteorological situations, terrain and topographical features can be changed at will and useful data translatable to the real - life situations can be obtained. These EWT studies carried out over the last ten years have greatly helped in determining the pollutant concentrations under various urban street canyon conditions as a function of building dimensions, upwind building configuration, wind direction with respect to building configuration and roof geometry. These studies have further shown that the vehicle- induced turbulence (or mixing) is an important factor influencing pollutant dispersion in urban areas particularly under low wind conditions, which are typical of street canyons. Most of the models do not adequately account for the vehicle - induced mixing leading to inaccurate and unreliable predictions, and sometimes even misleading conclusions.

In the present study, experimental data have been obtained at the EWT (2mx2mx16m) facility at the Indian Institute of Technology (IIT) Delhi to evaluate the effects of traffic parameters (traffic volume, traffic speed, traffic composition) on the pollutant concentrations in an isolated urban street canyon under heterogeneous (i.e., mixed) traffic condition(s). Tracer studies were carried by using 5% Acetylene and 95% Grade I Nitrogen and Flame Ionisation Detection (FID) technique. The tracer concentrations were non- dimensionalised to assess the effects of traffic - induced mixing on the pollutant concentrations at different heights in a simulated urban street canyon.

The study has indicated that at low wind speeds ($U_{ref} \leq 1.5$ m/s) and under perpendicular and oblique wind directions, pollution distribution in the urban street canyon

is affected by the weak central vortex whereas during parallel wind flow, the pollution gets dispersed due to channelling of the flow. However, under the heterogeneous traffic conditions, the effect of vehicle- induced mixing on the pollutant concentrations was found to be minimal at low traffic speeds (less than 10kmph) and low traffic volume (less than 1500 vehicles/ h) conditions, implying the need for maintaining a minimum traffic speed in the street canyons. Thus, while increase in traffic results in an increase in the pollutant levels in the street canyon, the effect of increased pollution level is, to a certain extent is offset by the increased vehicle - induced mixing generated by these vehicles.

The effect of vehicle- induced turbulence is significantly reduced with height (Z/H). The effect of the vehicle - induced mixing was found to be maximum at the breathing level, while at sampling locations close to the top edge, the effect of vehicle- induced mixing of pollution was found to be almost negligible. Further, the pollution level in street canyon has also been found to be affected by aspect ratio(s) and traffic volume(s).

Artificial Neural Networks (ANN) are being increasingly used for vehicular exhaust emissions modelling under the complex urban conditions. The present investigation also demonstrates the ability of these ANN models to simulate, the complex non - linear interaction between various variables, and predict the pollutant concentrations in an urban street canyon under mixed traffic conditions dominated by vehicle - induced effects.

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