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ENERGY EFFICIENT EXHAUST GAS EMISSION AND DISPERSION FROM ROOFTOP STACKS IN AN ACTUAL URBAN SETTING: A CASE STUDY IN NORTH CAMPUS OF THE UNIVERSITY OF ALBERTA

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ABSTRACT

Exhaust gases emitting from the rooftop stacks are recognized as one of the primary sources of urban air pollution. The complex urban airflow further transports these hazardous gases throughout the geometry and near the buildings' fresh intakes, increasing the chances of compromising the outdoor and indoor air quality. Building planners widely use analytical and semi-empirical dispersion models to assess the pollutant distributions field, leading to extremely conservative, less energy efficient guidelines in design and operation of the ventilation exhaust stacks due to the simplifying assumptions. In order to address this issue, this research will focus on integrating the exhaust gases emitting from the University of Alberta North campus buildings with the airflow field throughout the geometry in various meteorological conditions. The ANSYS CFX code is used to perform the numerical simulation by solving the 3D steady Reynolds-averaged Navier-Stokes (RANS) equations on a building-scale high-resolution grid. The pollutant is assumed as a passive scalar, meaning that due to its low mass fraction in the field and its non-reactive nature, its concentration does not affect the conservation of momentum or bulk continuity. Therefore, the transport equation can be solved after the flow field is modelled. For this reason, the validation study is performed in two steps. First, the CFD model performance in 24 cases (eight wind directions and three wind speeds) is evaluated by comparing the predicted flow fields with the available data from the previous measurement campaign performed at the North Campus. In the second step, the reliability of the implemented turbulence model, numerical algorithm, modeling techniques, and the grid generation scheme is further evaluated using the Mock Urban Setting Tests (MUST) dispersion dataset. Using the validated CFD model, the correlations between momentum ratios (M^*) of the rooftop stacks and the resultant normalized concentration (C^*) at the locations of interest (e.g., nearby fresh air intakes and building openings) under prevailing meteorological conditions will be determined. This research aims to identify the wind flow and dispersion features specific to this campus geometry, form benchmarks, and set guidelines for similar applications, which will further pave the way for more sustainable solutions in building operations where the exhaust rates can be adjusted according to real-time meteorological conditions to optimize the energy consumption.