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# Linking Aerodynamic Drag to Neighborhood-Scale Building Natural Ventilation Potential in Heterogeneous Urban Area

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Typical natural ventilation modeling involves coupling outdoor airflow CFD simulations with indoor airflow network models using CONTAM. However, directly scaling this strategy to the neighborhood or district level—which can include tens to hundreds of buildings—is computationally inefficient. At this larger scale, the primary concern often shifts from precise calculations to reliable estimations and performance comparisons.

This work presents a preliminary exploration that uses aerodynamic drag (*F*) as an indicator of natural ventilation potential. Extending previous work—which established that a single building's cross-ventilation rate (*Q*, $m^3/s$) is proportional to the square root of its drag force (√*F*, N)—this study applies the concept to the neighborhood scale. A RANS numerical simulation campaign is performed for a Nanjing district involving 20 residential neighborhoods (comprising 252 buildings up to 57 m high) located in a heterogeneous context that includes high-rise towers up to 330 m.

Results reveal that *F* is closely related to wind direction ( *!* ), building typology, orientation, and the shelter effect within the heterogeneous urban fabric. Using stepwise regression analysis, a nonlinear correlation formula is established between aerodynamic drag and key morphological parameters, specifically directional frontal area density (ǆ$_{f,!}$) and flow tortuosity.

Specifically, northern neighborhoods (#01 to #04) exert higher *F* due to less shelter from adjacent medium-height facility blocks. This high-drag condition can be leveraged for cross-ventilation in residential units with north-south layouts when internal doors are open. Conversely, neighborhoods #07 and #08 experience the lowest *F* and thus the lowest ventilation potential. For neighborhoods #01, #10, and #14, wind along the long axis of slab-shaped buildings creates high drag on shorter façades but a minimal pressure difference across main façades, thereby hindering effective cross-ventilation.

The present study provides a cost-effective approach for exploring spatial variations in natural ventilation potential at the neighborhood and district scales. The resulting dataset offers a valuable reference for aerodynamic parameterization and ventilation estimation within urban building energy simulations, supporting the development of more resilient and energy-efficient urban environments.