

Do We Really Need Fluid Mechanics in Urban Airflow Modelling?

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Abstract: Urban airflow modelling, whether conducted in wind tunnels or via computational fluid dynamics (CFD) simulations, is often treated as a “plug-and-play” exercise: build a reduced-scale model and test it in wind tunnel, or run a CFD simulation, and assume the results transfer directly to the real world. With state-of-the-art wind-tunnel facilities featuring automated data acquisition and increasingly user-friendly CFD software, it can seem possible to generate wind-tunnel and simulation results without a solid grounding in fluid mechanics. Yet, while we demand high-fidelity models that incorporate multiphysics effects such as solar radiation and evapotranspiration from greenery, we also expect one-click solutions that produce credible (and preferably colourful so they look legitimate) wind-field results. Do we, then, still need fluid mechanics in urban airflow modelling? This seminar addresses the question through the lens of similarity, focusing on the Reynolds number, which governs the flow regime and scaling. We compare flows in idealized street canyons across a range of Reynolds numbers to assess whether reduced-scale models can reproduce full-scale physics, and then extend the analysis to case studies of real urban districts. These comparisons show that there is no universal critical Reynolds number below which scaling effects become negligible, despite assumptions commonly made in the literature. Instead, the critical Reynolds number depends on urban morphology, including building height variability and layout. Heat transfer (non-isothermal effects) can further shift the threshold. The seminar concludes by summarizing recent findings on similarity in urban airflow modelling and proposing practical criteria for when simplified scaling assumptions are defensible.

About Speaker: Dr. Chew Lup Wai is an Assistant Professor in the Department of the Built Environment, College of Design and Engineering at the National University of Singapore (NUS). He is the principal investigator of the Airflow-Buildings-Cities Laboratory at NUS (<https://blog.nus.edu.sg/lupwai>). He obtained his PhD in Mechanical Engineering from Massachusetts Institute of Technology. Prior to NUS, he worked as a postdoctoral scholar at Stanford University. His specialization lies in urban airflow modelling, focusing on natural ventilation, outdoor wind field, and the physics of flows, using both experimental and numerical approaches. In his free time, he enjoys reading, painting and traveling.

More details at <https://cde.nus.edu.sg/dbe/staff/chew-lup-wai-dr/>