

INTEGRATION OF COMPUTATIONAL FLUID DYNAMICS INTO ARCHITECTURAL AND URBAN DESIGN WORKFLOWS: A METHODOLOGICAL FRAMEWORK

Marcell Bálint Nánási

Assoc. Prof. Dr. Viktória Sugár

Prof. Dr. István Kistelegdi

Óbuda University, Hungary

ABSTRACT

Urban environments are at the forefront of climate change impacts, making airflow simulation a key tool for shaping resilient and sustainable cities. This research investigates the integration of computational fluid dynamics (CFD) simulations into architectural and urban design workflows. The study aims to connect architectural and planning processes with CFD-based analysis of urban airflow. Simulating wind patterns, ventilation, and pollutant dispersion in dense urban environments provides valuable insights for architects, planners, and decision makers in the early design stages. A representative city fragment was modeled in a standard architectural CAD platform and imported into ANSYS Discovery and Fluent, one of the most widely adopted CFD solvers in both academic and professional contexts. The primary outcome is a practical workflow that links architectural modeling tools with engineering simulation software, enabling detailed analysis of airflow at the urban scale. Key challenges included model simplification, geometry preparation, and ensuring interoperability across platforms. Despite these difficulties, the workflow proved successful. The findings demonstrate that CFD-based urban airflow simulation is both feasible and beneficial, offering a robust methodological pathway for advancing sustainable and resilient urban design.

Keywords: Urban airflow simulation, Architectural design workflows, Sustainable urban design, Resilient cities, Computational Fluid Dynamics (CFD)

INTRODUCTION

The increasing importance of urban resilience and sustainability under climate change highlights the need for design strategies that improve environmental performance and adaptability in the built environment and mitigate Urban Heat Island (UHI) [1], [2]. Mitigating this phenomenon can benefit buildings, cities, suburbs, and the global [3]. One of the key elements in this is improving air quality on urban streets and addressing the low ventilation capacity of urban canyons formed by high-rise buildings [4], [5]. Several factors influence air flow in these areas. Understanding wind and airflow dynamics is crucial for designing resilient, sustainable cities.

Numerical simulation is widely regarded as one of the most effective methods for analysing the urban wind field. It offers several benefits, including ease of use, precise