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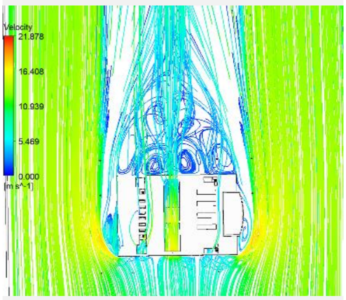
AIR FLOW AND POTENTIAL NOX DEGRADATION THROUGH PHOTOCATALYTIC WALLS AT URJC UNIVERSITY CAMPUS BUILDINGS

***C.Casado*[1]**, *R. Manzanares-Bercial[2], M. Martín-Somer[1], M. Cueto[1], M. Ogueta-Gutiérrez[2], S. Franchini[2] and J. Marugán[1,3] (1) Department of Chemical and Environmental Technology, ESCET, Universidad Rey Juan Carlos, C/ Tulipán s/n, 28933 Móstoles, Madrid, Spain. cintia.casado@urjc.es (2) Instituto Universitario "Ignacio Da Riva" (IDR/UPM), Universidad Politécnica de Madrid, Plaza Cardenal Cisneros, 3, E.28040, Madrid, Spain (3) Instituto de Tecnologías para la Sostenibilidad, Rey Juan Carlos University, C/ Tulipán s/n, 28933 Móstoles, Madrid, Spain*



NOx are potent greenhouse gases, contributing to the warming of the planet, adittionally, eliminating NOx from human environments is crucial for safeguarding public health as they contribute to the formation of harmful pollutants, which can exacerbate respiratory issues and lead to cardiovascular problems. In this work, the importance of high-fidelity geometry in modeling the velocity field around a building, and NOx transport, is studied. The results have been validated in a wind tunnel through local pressure coefficients and velocity values at pedestrian level, for various wind directions. The effect of placing a barrier against the transport of NOx is also studied, and, using a rigorous model of photocatalytic NOx elimination, the efficiency of impregnating the walls of the building with a photocatalytic paint in different situations is studied.

Introduction

Photocatalytic technology is a promising solution to mitigate air quality issues in big cities. It has been demonstrated that photocatalysis can mineralize most harmful contaminants, making it an effective tool for improving air quality. However, important problems associated with monitoring the efficiency of these solutions under real conditions remain [1]. Computational Fluid Dynamics (CFD) models are a valuable tool for predicting the effectiveness of environmental pollutant degradation. CFD models allow the simulation of fluid and gas behaviour in a specific environment, enabling predictions on how pollutants will disperse in the air and interact with surrounding surfaces.. CFD models can also be employed to optimize the design of facades to increase degradation through photocatalytic walls.

In this study, first, the transport of pollutants (NOx) surrounding a highly detailed geometry of a complex building, including features such as internal stairs and roof details, has been investigated using CFD, for understanding the aerodynamic behaviour and environmental impact of structures. We focus this study on the local peculiarities of the building and their influence, evaluating pressure coefficients at various locations on the building's facade. Then, the impact of using the building walls, and both walls and roof, as photocatalytic surfaces in the degradation of NOx originating from National Road A-5, which borders the university campus, was investigated.

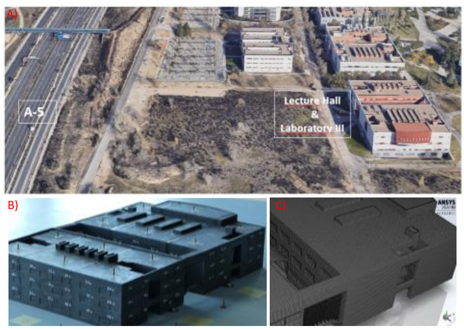


Figure 1. A) Location of the studied building, particularly exposed to pollution from the adjacent road (Google maps)**.** B) 3D printed and C) Computational model for the realistic studied buildings.

Material and Methods

The building is a 1:340 scale model of the Lecture *Hall III building* and *Laboratory III building* of the Rey Juan Carlos University Campus, in Madrid, Spain. These buildings have the particularity of being connected by a decorative structure that forms a semi-covered street between them. First, fluid dynamic results have been validated in a long test section wind tunnel used to model the atmospheric boundary layer (ABL) located in the facilities of Institute of Microgravity Research “Ignacio da Riva”, from Polytechnic University of Madrid. For this purpose, a 3D-printed scale model of the buildings, with the same CFD model dimensions, has been equipped with 194 pressure sensors over its 10 facades (near-wall) from which local pressure coefficients are obtained (see Figure 1B where sensors are shown). At pedestrian level, and over the roof, Irwin sensors are installed to obtain velocity values at different locations. The effect of wind direction has been also studied. The species transport method was used to introduce the NO pollutant, evaluating various aspects such as pollutant concentration levels, areas of higher concentration in the geometry, and the increase in concentration over time. This species transport method was applied for the initial geometry and the adittion of a rectangular barrier was additionally studied. A kinetic model for NO and NO_2 photocatalytic degradation, including adsorption over TiO_2 surfaces was coupled with wind modelling and transport of pollutants. The kinetic model also considers UV radiation reaching the photocatalytic walls. The kinetic model and kinetic constants were previously validated according to the ISO standard photoreactor [2]. ANSYS Fluent 2020 R2 was used for simulations. A mesh of 4M cells was required to get mesh-independent results (Figure 1C show mesh details).

Results and Discussion

As an example, Figure 2A shows results for one of the studied wind directions in different positions around the building, obtained with computational modeling and measured in the wind tunnel. The wind velocitys obtained at the pedestrian level in the internal semi-covered wall between buildings are also shown. Figure 2B and 2C additionally shows as an example the peculiarities in flow lines introduced by the rigorous model of the building's geometry and the transport of NO around this geometry.

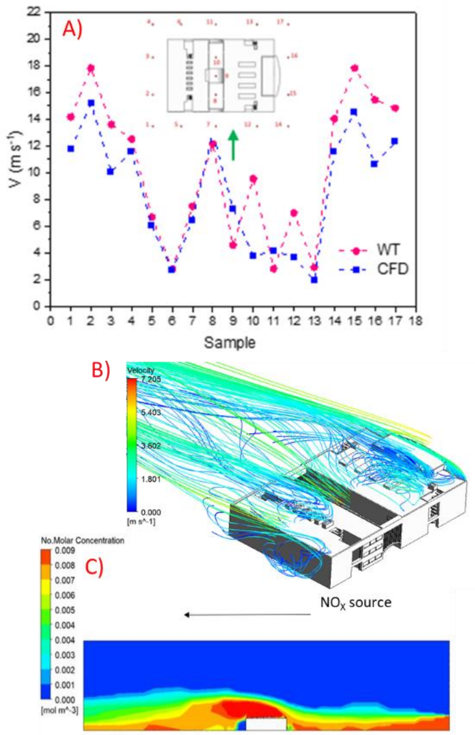


Figure 2. A) Comparison between modelled and experimental measurements. B) Streamlines around the university building. C) NOx transport.

Conclusions

This study helps ensure the accuracy and reliability of CFD models in predicting the wind-induced pressures on building surfaces, providing insights into how building layouts and features influence the dispersion of contaminants. The mechanistic model used for photocatalytic elimination allows estimating the viability of this technology under various conditions. We consider that the application of such rigorous mechanistic models can assist in decision-making regarding the air quality policies to be implemented.

Acknowledgments

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