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Development of a Data-Driven Automated Wing Wall Window for Enhanced Wind-Induced Ventilation in Buildings

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Abstract: In the Philippines, the hot and humid climate makes natural ventilation essential, particularly since many households rely on single-sided façades and cannot afford air-conditioning. A widely used passive solution is the wing wall, which channels outdoor wind into the living space to improve airflow and cooling. However, conventional wing walls are inherently limited: their performance depends heavily on wind speed, direction, and installation angle, meaning one fixed design cannot ensure consistent ventilation. To address this challenge, our project introduces a data-driven, adaptive wing wall window that automatically adjusts in real time to changing wind conditions. The study begins with controlled wind-tunnel experiments that reproduce atmospheric boundary layer (ABL) behavior. Using the tracer gas method, we evaluate ventilation effectiveness and then construct a prototype. Experimental results are used to train an artificial neural network (ANN), which generates predictive airflow response curves. These predictions are further validated with CFD simulations before being integrated into the automated prototype. The expected outcome is an intelligent, responsive window system that not only enhances indoor air quality and comfort but also reduces reliance on energy-intensive air-conditioning. By aligning passive design with machine learning, the project aims to deliver a scalable solution for healthier and more sustainable homes in the Philippines.

Key Words: Wing wall, Wing wall window, Automated adjustable wing wall window prototype, Ventilation, Single-sided ventilation, CFD, Air Change Rate, Purging Flow Rate

Authors: IGLESIA, Joshua Alain (Energy-Environment Interaction (E2I) Laboratory, Department of Mechanical Engineering and Technology, College of Engineering, MSU-Iligan Institute of Technology Iligan, Philippines); JACINTO, Carlos Miguel (Energy-Environment Interaction (E2I) Laboratory, Department of Mechanical Engineering and Technology, College of Engineering, MSU-Iligan Institute of Technology Iligan, Philippines); ALLANIC, Clint (Energy-Environment Interaction (E2I) Laboratory, Department of Mechanical Engineering and Technology, College of Engineering, MSU-Iligan Institute of Technology Iligan, Philippines); ENTERIA, Napoleon (Energy-Environment Interaction (E2I) Laboratory, Department of Mechanical Engineering and Technology, College of Engineering, MSU-Iligan Institute of Technology Iligan, Philippines)

Presenter: ENTERIA, Napoleon (Energy-Environment Interaction (E2I) Laboratory, Department of Mechanical Engineering and Technology, College of Engineering, MSU-Iligan Institute of Technology Iligan, Philippines)

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