

# **A NOVEL STRATEGY OF ENVIRONMENTAL PERFORMANCE-DRIVEN BUILDING DESIGN WITH WIND TUNNEL AND CFD SIMULATION**

## **1. Aims and methods used**

Environmental performance simulation conducted in the early design stage can help architects understand the relationship between building geometry and the resulting aerodynamic effects both qualitatively and quantitatively. In this way, architects are able to make more responsible decisions. This workshop aims to encourage participants to understand and start to apply physical wind tunnel and digital CFD tools to guide urban and building design during the early design phase, while making environmental performance the driving force of building arrangement and generation.

Firstly, the basic theory about the interactive effect between outdoor airflow and buildings will be introduced. Then, a series of conceptual building arrangement design will be proposed according to nine-rectangle-grid. After that, the aerodynamic effects of different building combination patterns using custom-made mini wind tunnel and CFD software will be studied. Furthermore, multiple sets of experiments will be conducted with controlling parameters of building arrangement and height in nine-rectangle-grid (3\*3).

## **2. Technical requirements**

Two main tools, wind tunnel and CFD software, are usually applied to simulate for analyzing wind environment. In physical tests, smoke wire and scouring experiment in mini wind tunnel can be installed to visualize the air flow surrounding objects. Physical tests provide a fast and intuitive platform for building form and arrangement finding qualitatively, while digital CFD software simulation could generate multi-testing points results for quantificational analyze.

## **3. List of necessary facilities such as fabrication machine, software, and materials**

Fab-Union will support participants the mobile mini wind tunnel equipment (3m length) and test models.

The participants need to be proficiency in two digital software: Rhino & Grasshopper

## **4. The resulting size of the workshop to be exhibited at CAADRIA**

The final exhibit will appeal a series of (predicted more than 30) physical nine-rectangle-grid model with the size of approximately 9\*9\*5cm, which shows the results of simulations about appropriate building volumes arrangements. Meanwhile, their airflow simulation results from wind tunnel and CFD will also be displayed with printed pictures respectively.

## **5. Schedule of workshop including online preparation phase, if necessary**

Day 1 (morning): (1) Introduction of theory of air flow and the interactive influence between outdoor wind environment and buildings; (2) Introduction of wind environment simulation tool: wind Tunnel and CFD; and (3) Introduction to the work flow of this two-day workshop, including the visualization methods and the explanation of some basic aerodynamic phenomenon.

Day 1 (afternoon): Design phase 1: (1) Conduct Scouring Visualization Experiment and

analysis of wind phenomena and wind shadow area, the test based on a series combinations of square volumes; (2) Apply Smoke Wire Visualization Experiment and analysis the airflow trace as well as the pattern of wind. Furthermore, illustrate the evaluation criteria for different air flow patterns;

Day 1 (evening): Participants will download and install software and plug-in we programmed from cloud storage we will offer for the preparation of CFD simulation next morning.

Day 2 (morning): Design phase 2: develop the 3D digital models selected from last afternoon and apply CFD Simulation after mesh, parameter settings as well as calculation for quantify wind speed and wind pressure at different profile heights.

Day 2 (afternoon): (1) Producing Final Model and (2) Final Production and Exhibition Set Up

## 6. External sponsor / supporting company

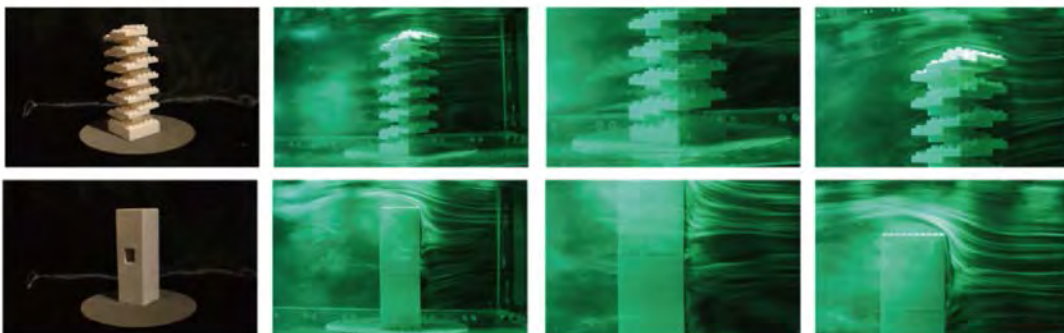
Shanghai Fab-Union Architectural Technology and Digital Fabrication Co., Ltd.

## 7. Two or three reference images

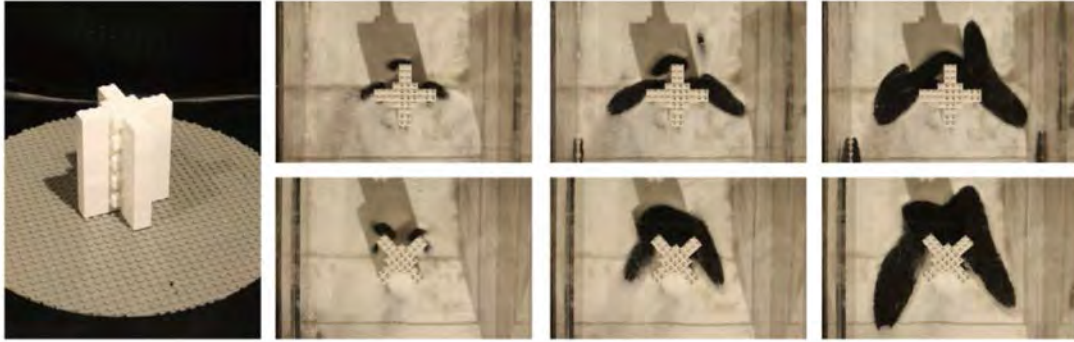
(1) Mini wind tunnel



(2) Smoke wire experiment



(3) Scouring experiment



## **8. Resume (CV) of the workshop tutor(s) indicating previous experiences in the proposed area**

### **Prof. Philip F. Yuan:**

Professor of College of Architecture and Urban Planning (CAUP), Tongji University., PHD tutor, founder & director of Archi-Union Architects and Fab-Union Intelligent Engineering Co. Ltd; In recent years, Philip F. Yuan focuses on performance-driven digital design methods and digital construction methods of research and practice. He has guided six years' DigitalFUTURE Shanghai Summer Workshop which hosted by the Collage of Architecture and Urban Planning, Tongji University. He has advised several groups in the related area in workshops.

### **Dr. Jiawei Yao:**

Post-doctor in College of Architecture and Urban Planning (CAUP), Tongji University; PhD in the University of Nottingham, UK; Exchange Scholar in the University of Hong Kong; Depth research of urban micro-climate, outdoor thermal comfort, indoor and outdoor wind environment simulation with wind tunnel and CFD; have completed related research about regional historical wind environment simulation and comparison in Lujiazui, Shanghai, and [proposed](#) some novel urban design strategies according to pedestrian wind comfort.

### **Jingyun Zheng:**

Master student of College of Architecture and Urban Planning (CAUP), Tongji University., Research direction is about hot pressure wind tunnel of architecture, and quite familiar with wind tunnel and CFD simulation for outdoor airflow.