Wind Engineering Joint Usage/Research Center
FY2019 Research Result Report

Research Field: Wind Hazard Mitigation/Wind Resistant design
Research Year: FY2019
Research Number:
Research Theme: Wind tunnel tests and CFD simulations of gust wind speeds at the pedestrian-level around super-tall buildings with various configurations

Representative Researcher: Dr. Bowen YAN

Budget [FY2019]: 400000JPY Yen

There is no limitation of the number of pages of this report.
*Figures can be included to the report and they can also be colored.
*Submitted reports will be uploaded to the JURC Homepage.

1. Research Aim

The outdoor wind and thermal comfort are of great significance for urban residents in high-density cities due to their close correlation with people's outdoor activities and living conditions. The available literature in regard to the pedestrians' outdoor wind and thermal comfort indicated that the wind velocity is of primary concern. In addition, the architectural features have been found to have played an important role in modifying the wind flows and thermal conditions at the pedestrian level in the vicinity of buildings. Therefore, the pedestrian-level wind (PLW) environment should be accurately assessed to achieve the optimal design scheme in favor of people's outdoor activities. The wind gust, the fluctuations of wind at small time scale (~seconds), was expected to be covered in the wind comfort assessment. The aims of this study include: 1) to establish the benchmark experimental study for the gust winds around various generic tall buildings at the pedestrian level; 2) to validate various CFD approaches for the gust wind evaluations at the pedestrian-level around super-tall buildings.

2. Research Method

This research combines the wind tunnel and numerical simulations in a consistent way. Firstly, wind tunnel tests were conducted by hot wire probe and PIV system to measure the gust wind speeds at the pedestrian level around the scaled model of various generic tall buildings. Secondly, the validation of CFD simulations were performed to predict the gust wind speeds at the pedestrian level around tall buildings against the corresponding experiments. The assessment using different CFD approaches were performed on the sensitivities of mesh resolution, computational domain size, lengths of discretization time step and sampling period, inflow turbulence generation methods and turbulence model.

The outcomes of this study are expected to clarify the significance of gust wind speeds on PLW environment assessment and establish the high-fidelity numerical simulations to predict the gust winds around tall buildings at the pedestrian level.

3. Research Result

To assess the influence factors on the sensitivities of numerical simulations, a set of parameters were considered in terms of different turbulence models, grid meshing resolutions, inflow turbulence generation methods and sampling period.

Summary of the research

- Flow field in the TPU Simulator was characterised
- Mean Velocity and Turbulence Intensity variation were determined
- Pressure Coefficients on Cube Model of Building was obtained.
- Similar studies using TTU Building model is being performed at Tongji University and Iowa State University
- Results from these simulators will be compared

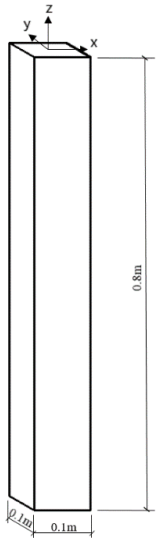


Figure 1 Model dimensions

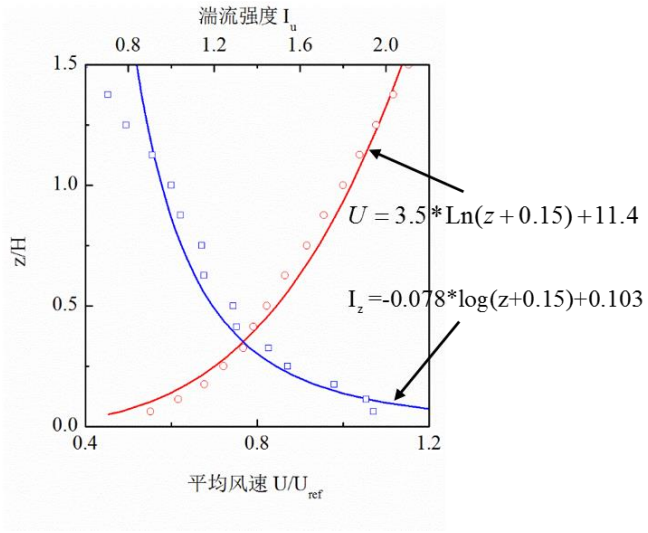


Figure 2 Mean wind speed and turbulence intensity profiles

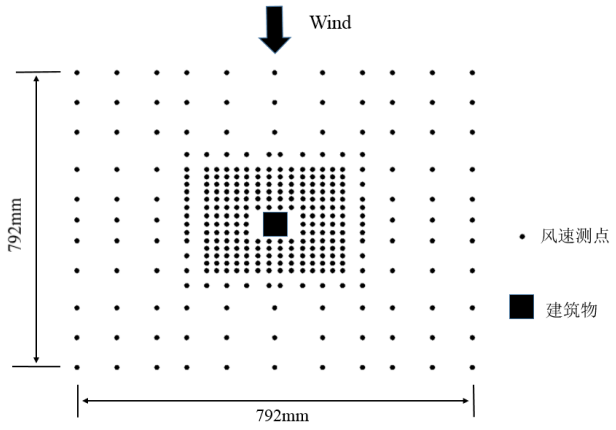
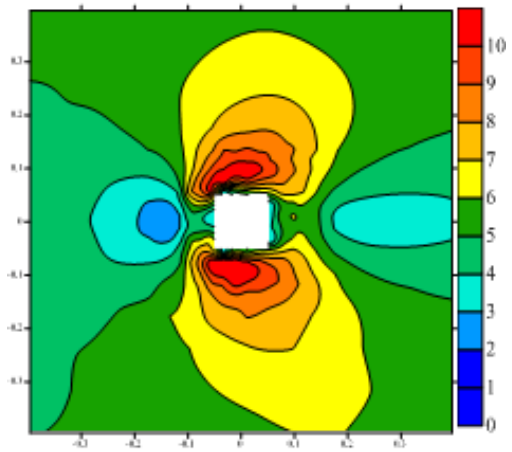
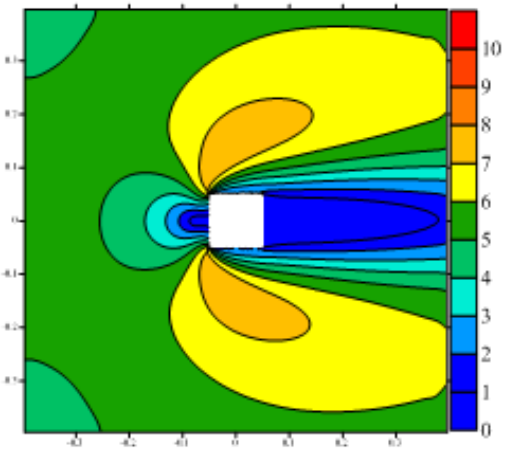


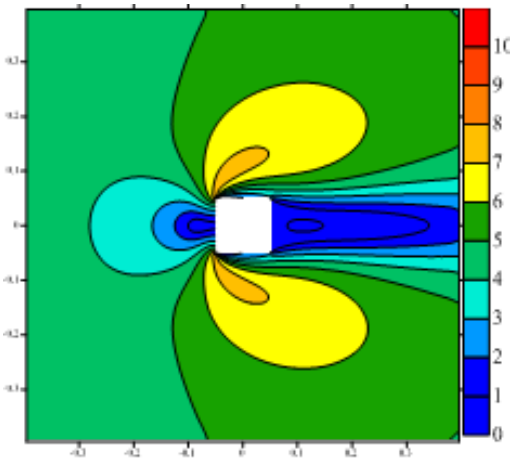
Figure 3 The distribution of wind speed probes



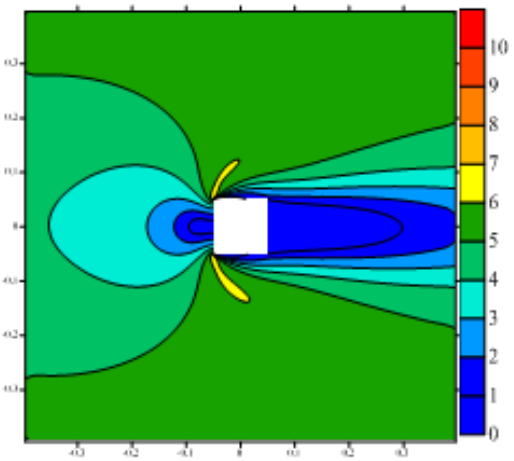
（a） **Experimental results**



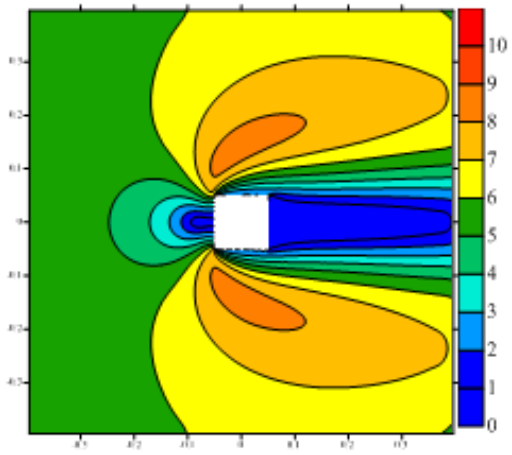
（b） **standard *k-ε* model**



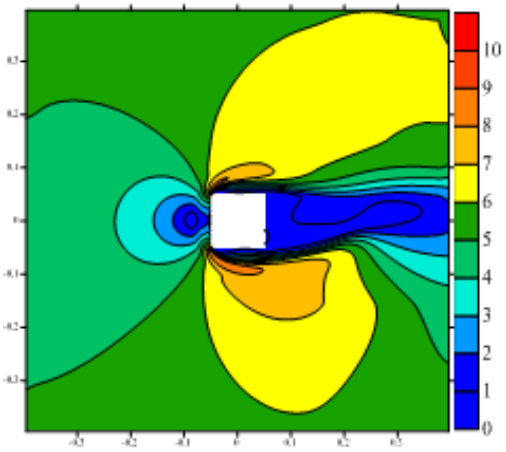
（c） ***RNG k-ε* model**



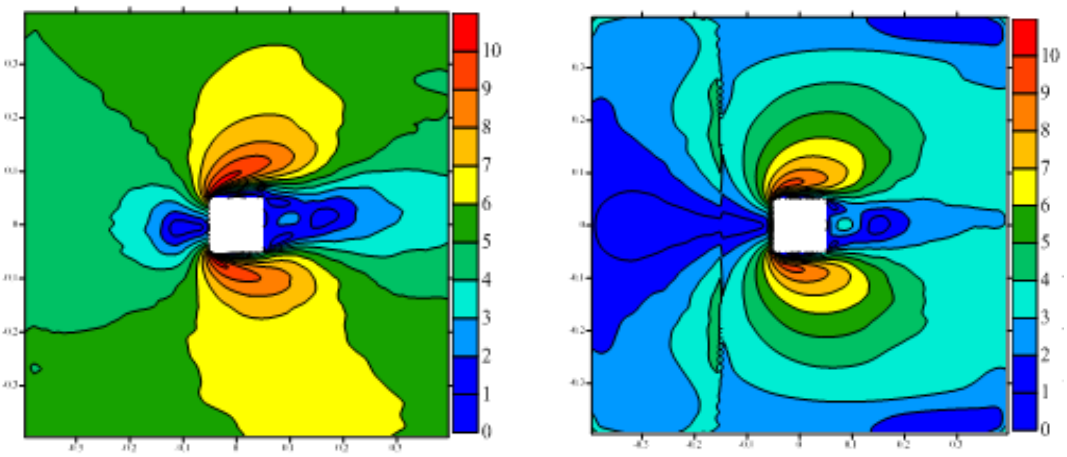
（d） ***Realizable k-ε* model**



（e） **standard *k-ω* model**



（f） ***SST k-ω* model**

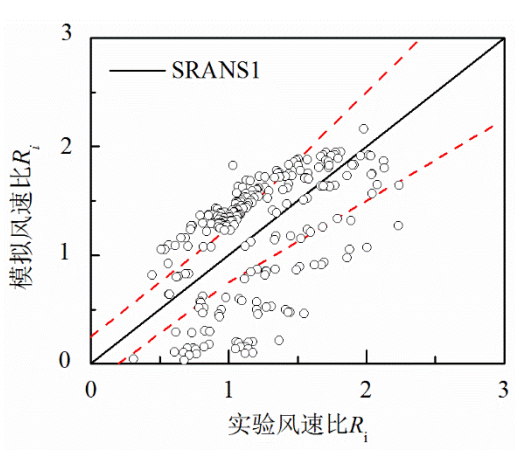


（g）DSRFG method **（h）CDRFG method**

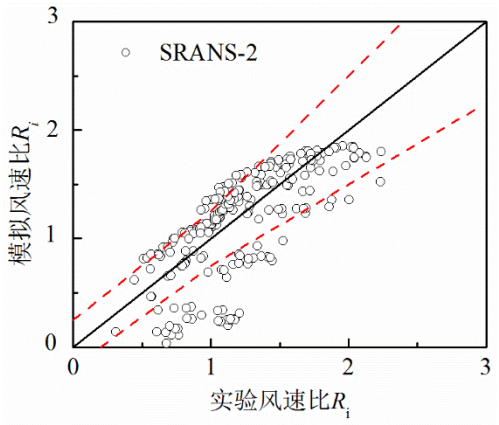
Figure 4 Comparison between CFD numerical simulation and wind tunnel test results

Table 1 Evaluation index values for different cases

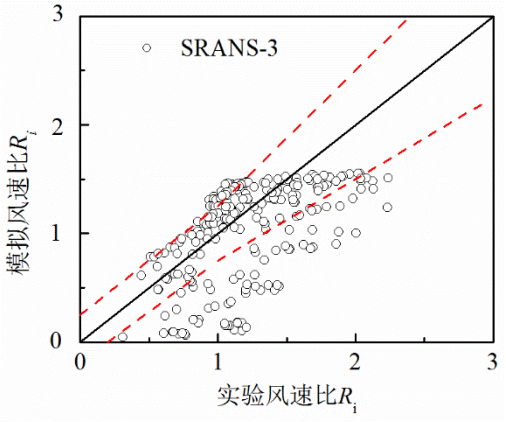
Index	Standard *k-ε* model	*RNG k-ε* model	*Realizable k-ε* model	Standard *k-ω* model	*SST k-ω* model	DSRFG	CDRFG
q （R_i>1.0）	0.716	0.740	0.636	0.663	0.675	0.883	0.765
δ （R_i>1.0）	0.271	0.193	0.225	0.296	0.219	0.100	0.156
σ （R_i>1.0）	0.342	0.288	0.331	0.348	0.302	0.152	0.206
q （R_i<1.0）	0.650	0.711	0.609	0.577	0.701	0.907	0.832
δ （R_i<1.0）	0.371	0.334	0.474	0.357	0.328	0.132	0.240
σ （R_i<1.0）	0.514	0.437	0.593	0.469	0.458	0.184	0.287



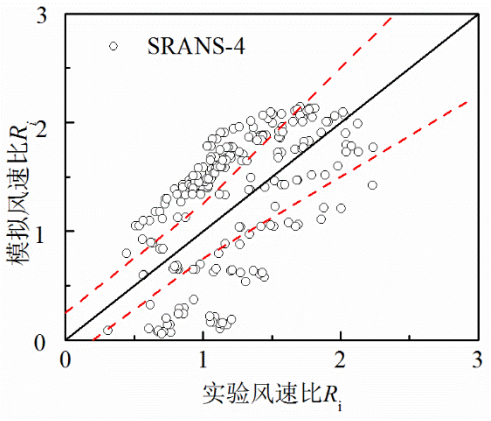
（a） standard *k-ε* model



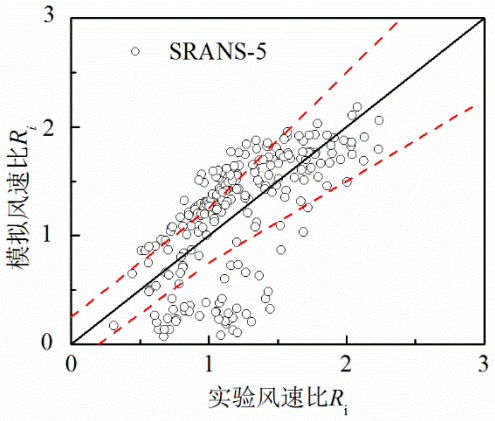
（b） *RNG k-ε* model



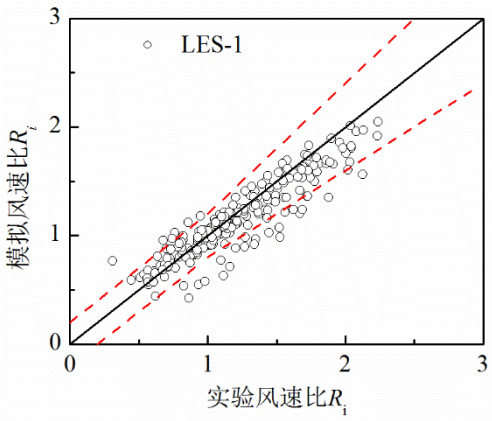
（c） *Realizable k-ε* model



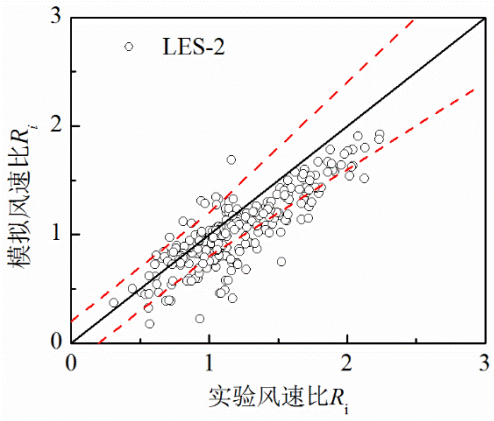
（d） standard *k-ω* model



（e） *SST k-ω* model



（f） DSRFG 方法



（g） CDRFG method

Figure 5 Distribution results of the evaluation index q value of different test cases

4. Published Paper etc.
[Underline the representative researcher and collaborate researchers]

[Published papers]
1. Nil
2.

[Presentations at academic societies]
1. Nil

2.

[Published books]
1. Nil
2.

[Other]
Intellectual property rights, Homepage etc.

5. Research Group
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2. **Associate Prof. Yingli Xuan (TPU/WERC member, PI)** Tokyo Polytechnic University Wind Engineering Research Center
3. Prof. Qingshan Yang (Co-Researcher) Professor, School of Civil Engineering, Chongqing University No.83 North St., Shapingba District, Chongqing, CHINA.

6. Abstract (half page)

Research Theme: **Researches on tornado flow characteristics and their effects on wind loadings**

Representative Researcher (Affiliation): Dr Sabareesh Geetha Rajasekharan (BITS-Pilani, Hyderabad Campus)

Experiments were conducted by exposing a rectangular building model to a tornado -like flow simulator at Tokyo Polytechnic University and velocity field was characterized. Pressure coefficients were obtained on the surface of these models at different locations with respect to the tornado vortex. Also peak minimum pressure coefficients on building model when exposed to translating tornado -like flow was also obtained. The same will be benchmarked with results of identical cases obtained from ISU, USA and Tongji University, China results. Figure.1 shows the flow visualization depicting tornado-like flow and Fig.2 depicts the pressure coefficients on the building model when placed at same location on both sides of the vortex.

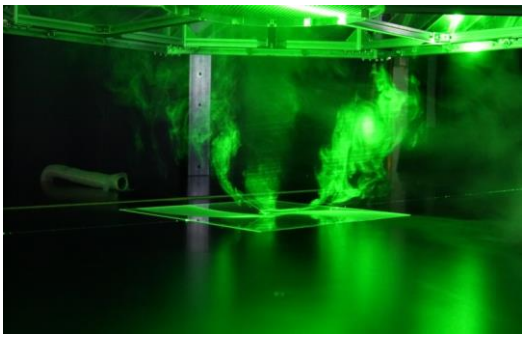

Fig.1 Flow Visualization of tornado-like vortex

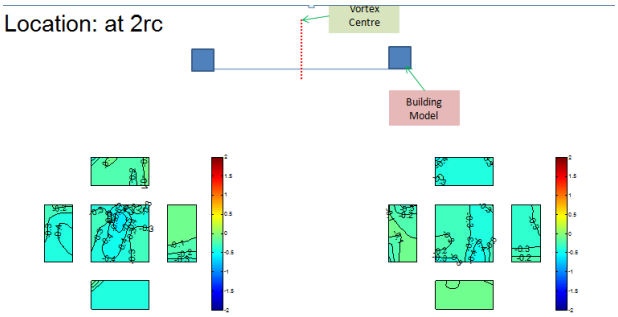

Fig.2. Pressure coefficients on exploded face of building model