Evaluation of k-epsilon models for simulating wind-induced mean airflow field and dispersion around a rectangular multi-storey building

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INTRODUCTION

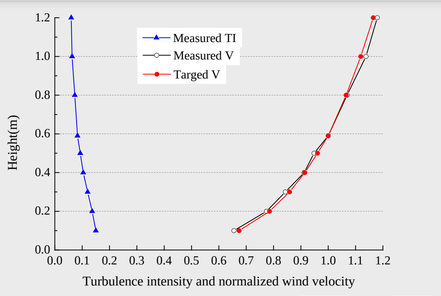
The airflow patterns related to multi-storey buildings with openings are lack of investigation. Steady RANS model is a widely used approach for dispersion modelling in many applied studies refer to actual buildings. The most commonly used method to evaluate the CFD models is through the comparisons between CFD results and experimental data.

PURPOSE

- To explore the airflow patterns in and around a rectangular six-storey building with single-sided natural ventilation.
- To measure and simulate the pressure coefficient and pollutant concentration field in and around the building.
- To evaluate the performance of three *k*-ε turbulence models.

METHODS

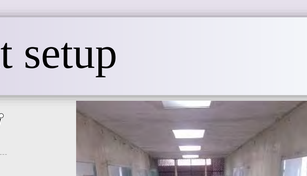
Experiment setup



$$\frac{U(h)}{U_{\mathrm{ref}}}=\left(\frac{h}{h_{\mathrm{ref}}}\right)^{\alpha}$$

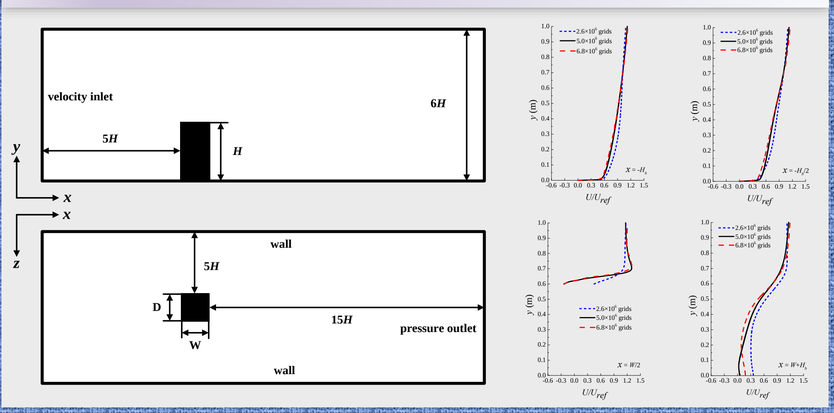
Release and detection of SF_6 INNOVA 1303 and 1412i

- The power law exponent of coming wind velocity profile is 0.22.
- The reference velocity at the building height is 2.89m/s, the corresponding Reynolds number is 1.15×10^5.
- The tracer gas sulphur hexafluoride (SF_6) was employed to simulate the pollutant.



●source location
■sample location
▲pressure taps

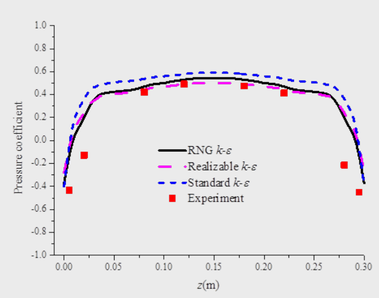
Numerical simulation configuration



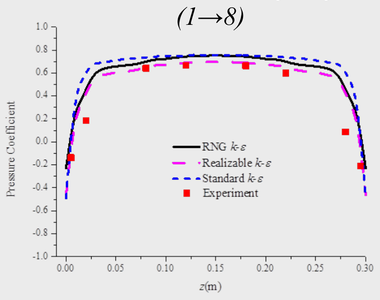
DISCUSSION

Pressure coefficient distribution

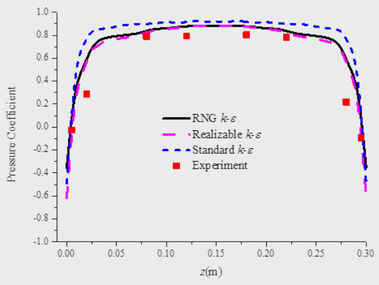
$$P_c=\left(p_{\mathrm{s}}-p_{\mathrm{ref}}\right)/0.5\rho U_{\mathrm{ref}}^2$$



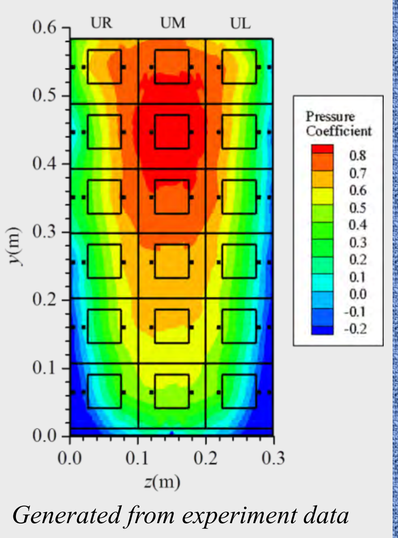
Horizontal lines at the first floor (1→8)



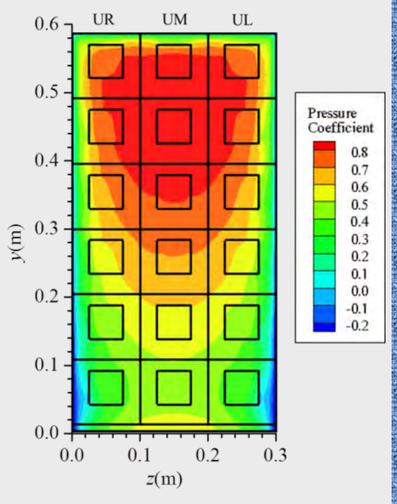
Horizontal lines at the third floor (1→8)



Horizontal lines at the fifth floor (1→8)



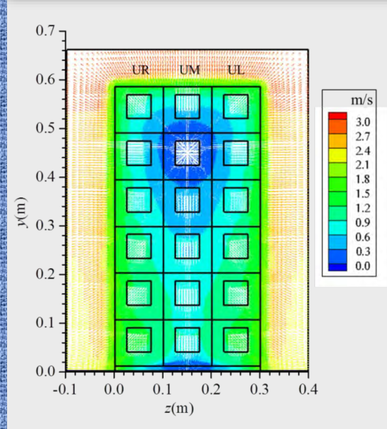
Generated from experiment data



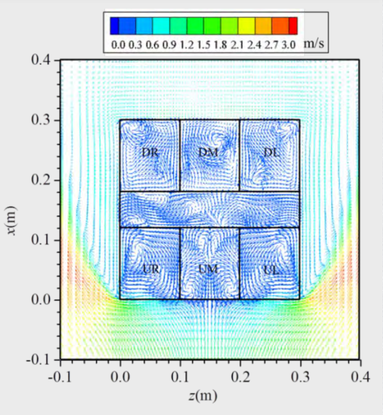
From realizable k-ε model

- The pressure coefficient distribution reflected a good symmetric tendency.
- The highest *Pc* value was up to 0.8 around the window area of UM5th unit, forming the stagnation zone.
- The qualitative *Pc* distribution reflected from experiment and realizable *k*-ε model agreed well at most area of "U" façade.
- Main discrepancies exist in the near-edge region, especially the top and bottom edge.

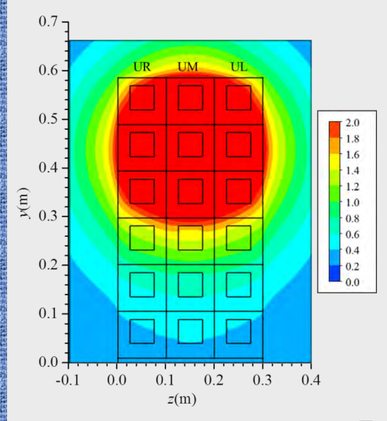
Tracer gas concentration distribution



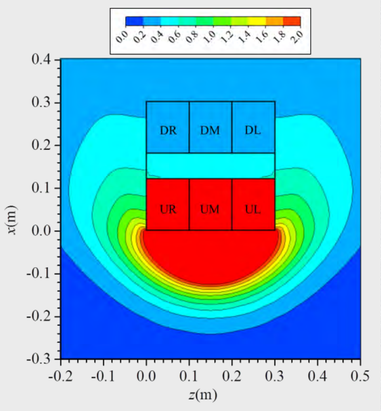
Airflow patterns at "U" façade



Airflow patterns in horizontal section at the source location height

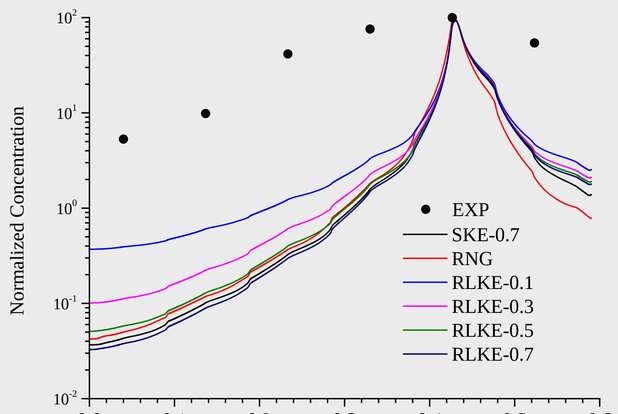


Tracer gas mass fraction at "U" façade



Tracer gas mass fraction in horizontal section at the source location height

- The concentration levels along the test line decreased with the distance from the source location.
- All the CFD results under-predicted the concentration obtained by the wind tunnel tests.
- The lowest value in the experiment is above 1 when the source is 100. The concentration descends rapidly from the source in the simulation.
- The difference between simulation and experiment results were up to one order of magnitude.



Comparison of normalized concentration along the centre vertical line of UM column

CONCLUSION

- The steady flow patterns reflected by the RANS models could be a qualitative reference to help analyzing the gaseous pollutant dispersion paths.
- The quantitative concentration distribution was underestimated both on upward and downward dispersion.
- The concentration distribution results are sensitive to the value of S_{ct}.
- More precise numerical method considering the concentration unsteady characteristics are worth of exploring.

Acknowledgement:

The State Key Laboratory of Civil Engineering for Disaster Prevention, Tongji University
The Natural Science Foundation of China (No.51278348)

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