Promotion and control of natural ventilation using fluid diode

Part 2 Comparison study on the performance of two fluid diode plate shapes by CFD

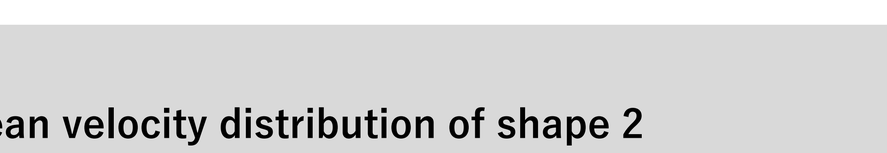
Research aim

- To compare the performance of shape 1 (Optimized in our research) and shape 2 (Cao et al.)[1)]
- To check the performance of airflow control when shape 1 or shape 2 was placed as an opening of a building model

Research method

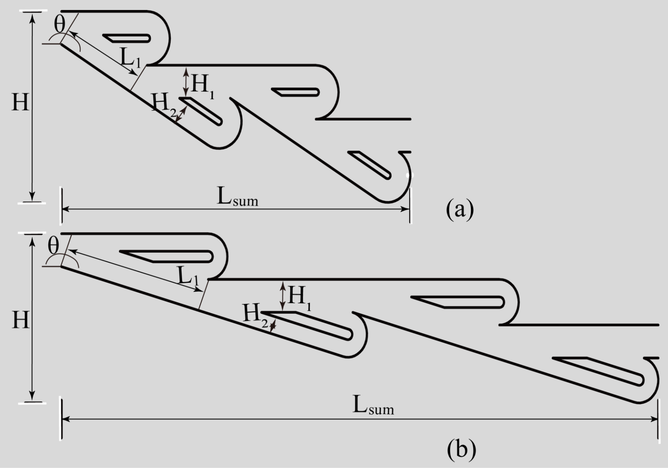
- 2D CFD for obtaining the minor loss coeficient ζR and ζF of shape 1
- RANS k-ω SST model
- From left reverse flow
- From right: forward flow

Reynold number	205, 450, 901, 1351, 1802, 2048, 3071, 4095, 6143, 8190, 10237, 12285, 15356, 18428
Inlet velocity	$v = \frac{Re \times \nu \times \alpha}{H_1}$ ここで、α =1



Shape of FDP and simulation results

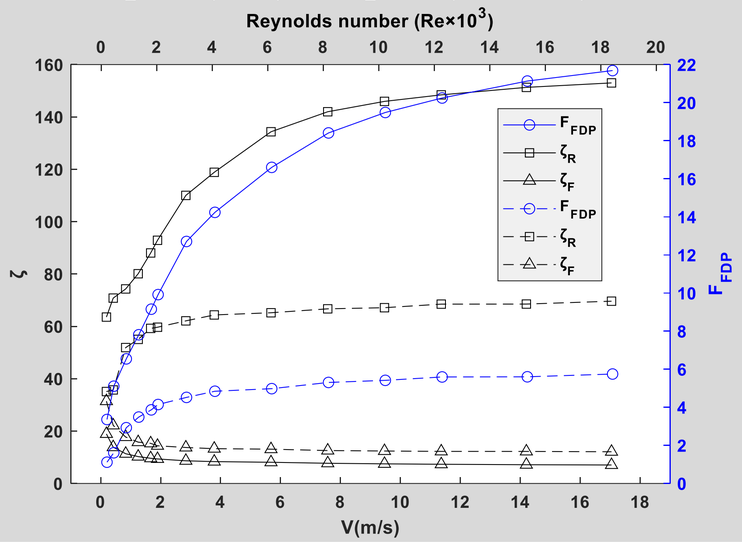
shape 1 (a) and shape 2 (b)



parameter details

Parameter	shape 1	shape 2
H_1 (mm)	5.00	5.00
H_2 (mm)	3.58	2.66
H (mm)	29.04	25.67
L (mm)	15.00	26.77
L_{sum} (mm)	63.02	107.82
Θ (rad)	$\frac{7}{6}\pi$	$\frac{13}{12}\pi$

shape 1 (line), shape 2 (dot line)

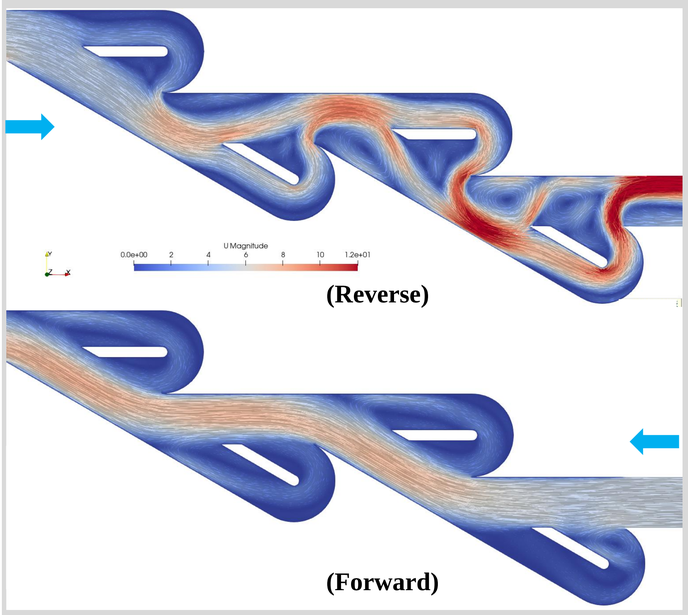


Simulation results

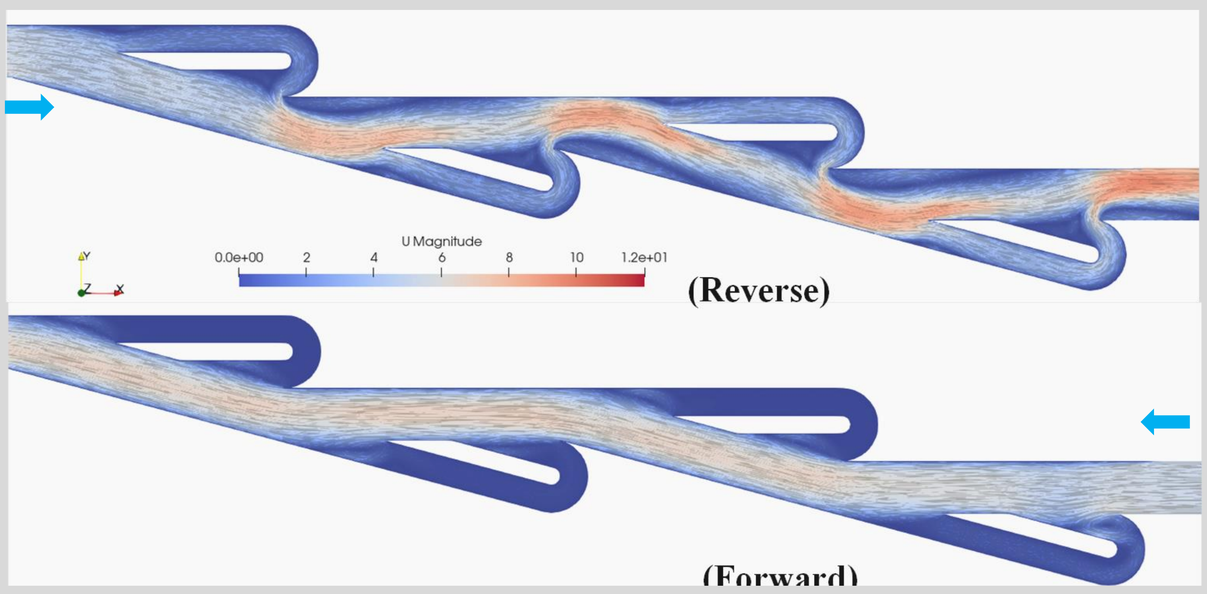
(Reynold number is 1802)

- A large pressure loss occurs in the reverse flow of shape 1, especially in the third and fourth loops.
- A little vortical flow is seen in the reverse flow of shape 2.
- Small pressure loss occurs in the forward flow of both shape

mean velocity distribution of shape 1



mean velocity distribution of shape 2

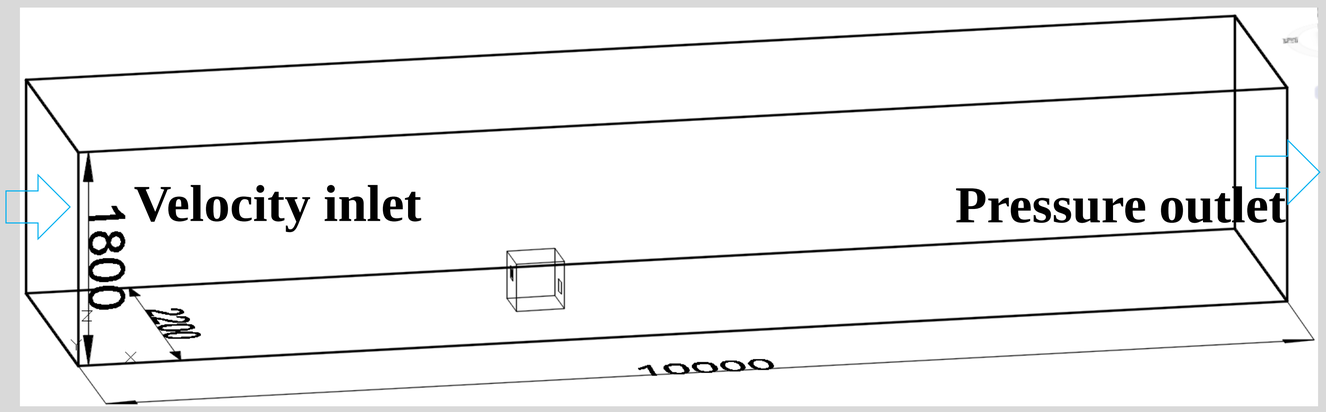


Airflow control analysis in building

- Using CFD
- RANS realizable k-ε 2-layer turbulence model
- Building model: 400*400*400 mm^3 (opening: 100*100 mm^2)
- Study case:

Forward opening	General window (considering the porosity of shape: 0.51*0.51 mm^2) , shape 1, shape 2
Roof height velocity	3.0, 4.6, 6.2, 7.8 m/s

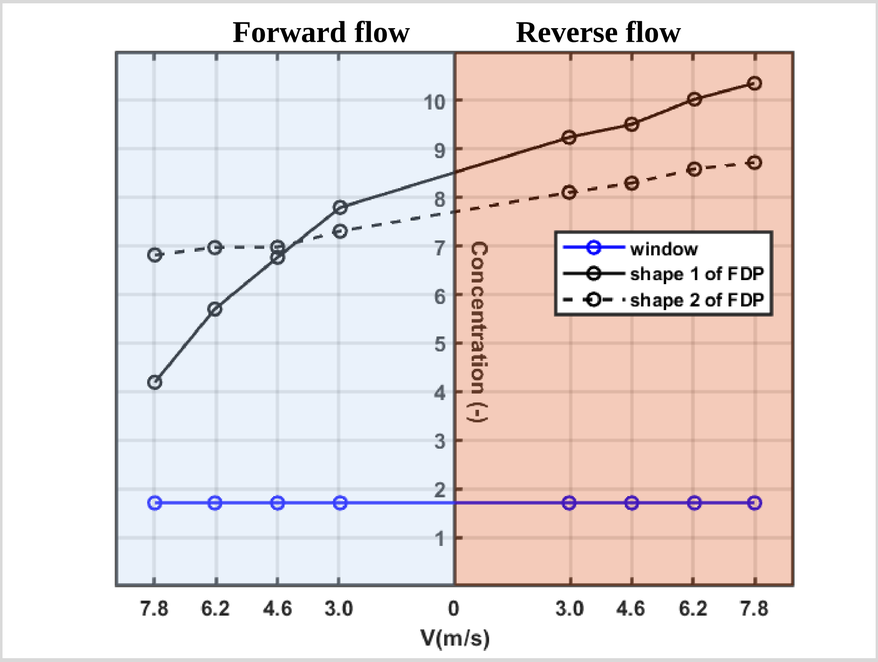
- A pressure jump, corresponding to minor loss coefficient ζF or ζR, was created on the front opening to make the flow easy or difficult to pass through the room.
- CFD simulation domain



Simulation results

- Normalized concentration for comparing the performance in airflow control
- $C_n = \frac{C}{C_o}$, $(C_o = \frac{1 \times V}{v L_o^2})$

Where, C_n denotes the normalized concentration (-); C denotes the indoor concentration (m3/s・ppm); V denotes the building volume (m^3, Tracer gas was emitted uniformly in the room at an emission rate of 1 ppm/s); v denotes reference velocity at roof height (m/s); L_o denotes the length of opening (m).



1) Z. Cao et al., Novel fluid diode plate for use within ventilation system based on tesla structure, Build. Environ. 185 (2020)

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