The attenuation of ventilation performance caused by neighbouring buildings can be observed clearly in Figure 5 for both square and staggered arrays. The windward opening of each building was blocked by the building located in front of it, except in Sq_1. Surprisingly, and in contrast with the reference case, the flow entered the building positioned at centre row in square array through the leeward opening, resulting in negative wind speed values. The skimming flow regime generated behind the building due to the street canyon effect allowed air to infiltrate through the leeward opening. However, this phenomenon did not appear in Sq_3. In Sq_4 and Sq_5, identical flow patterns and ventilation rates were exhibited. The results of staggered layouts indicate that the flow rate entering the building is higher when compared to the results of square arrays, especially in the case of St_2. The asymmetrical arrangement of the staggered layout produced an irregular pattern in St_2, St_3, and St_4, even though these were located in the same row. Based on the law of mass conservation, the ventilation rate in each building was computed using the following expression (Jiang and Chen, 2001):

$$Q = \frac{1}{2}\sum_{j=jm}^{jn}\sum_{k=km}^{jn}\left|U_{j,k}\right|\Delta y_j \Delta z_k, \quad (2)$$

where $U_{j,k}$ is the mean velocity normal to the grid ($\Delta y_j, \Delta z_k$) at the opening. Table 1 summarizes the ventilation rates obtained for each position.

Table 1. *Ventilation rate, Q (m^3/s) for each building position. (Iso: Isolated case)*

Case	Iso	Sq_1	Sq_2	Sq_3	Sq_4	Sq_5	St_1	St_2	St_3	St_4
Q	0.048	0.045	0.004	0.009	0.006	0.006	0.040	0.024	0.022	0.023

The flow patterns demonstrated by both arrays indicate quite clearly that the arrangement of buildings influences wind-induced ventilation behaviour. Apparently, the ventilation rate in building is not affected so much when the position is changed in a horizontal direction. However, the ventilation rate in buildings placed in subsequent rows decreases significantly, when compared to that in front-row buildings that receive direct wind flow without any intervening obstacle. Nonetheless, this argument requires further validation because rows of buildings used in this study might be insufficient to highlight ventilation performance trends in a streamwise direction.

CONCLUSION AND IMPLICATIONS

The prevailing wind characteristics should be able to meet natural ventilation requirements in order to obtain the desired ventilation rate inside buildings. The present study was performed using the RANS SST k-ω model on a group of nine blocks arranged in square and staggered layouts, to assess the modification of airflow in wind-ventilated buildings. A model validation study confirmed the reliability of this model in predicting wind-induced ventilation. The outcomes showed that in a square array, with spacing equal to *H*, the skimming flow generated behind the building allowed air to infiltrate through leeward openings. It was also noted that the number of buildings in a spanwise direction did not affect the ventilation rate. However, the ventilation rate of the same building used in the square array was remarkably increased when it was moved by distance *H*, as in the staggered array. This suggests that a staggered building layout could potentially enhance ventilation performance. Nonetheless, it is important to acknowledge the limitations of this study, including the use of a generic simplified cubic model. The size and position of openings were not addressed in this study, which were also limited to only one wind direction and that may be different in reality. A further limitation is that the effect of the reproduction range of the number of surrounding buildings was not considered. These factors should therefore be considered in future studies for better cross ventilation design. Despite these shortcomings, the results presented in this study contribute to the existing state of knowledge regarding cross ventilation, which is of interest for promoting green urban development.

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