Applying Digital Technologies for Sustainable Design: An Analysis of Vegetation's Impact on Courtyard Microclimate

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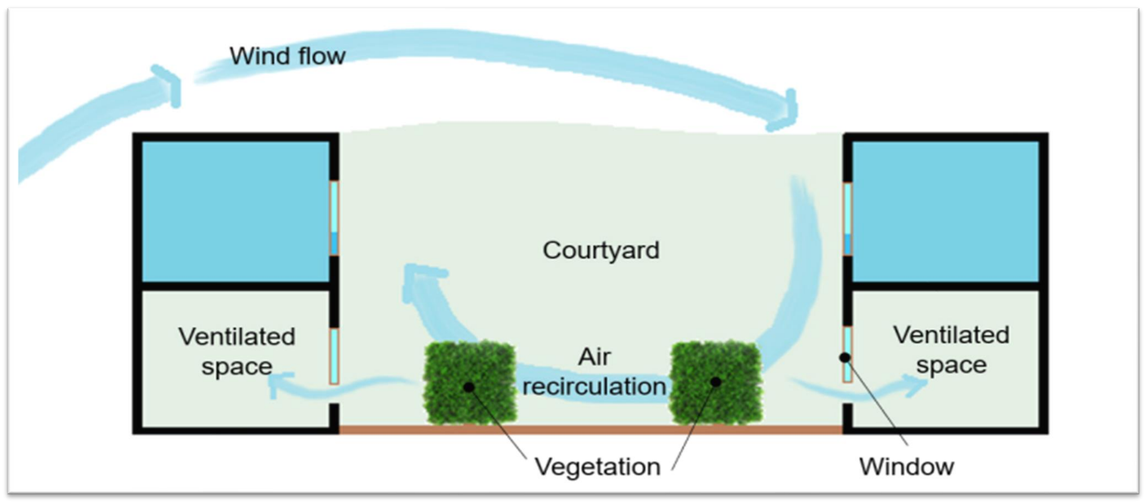
Background

- Courtyard architecture is a common passive cooling strategy that can improve indoor comfort through the influences of natural ventilation and thermal radiation.
- Vegetation is a prevalent passive cooling strategy that can enhance the thermal performance of buildings through the processes of evapotranspiration and shading effects.
- The impact of different sizes of vegetation on the indoor wind-thermal environment and thermal comfort assessment of courtyard buildings can be compared through numerical simulation methods.

Methods & Results



- **Case 1. Baseline enclosed courtyard model with no vegetation**
- **Case 2. Four small trees (1.5 m height) inside the courtyard**
- **Case 3. Four large trees (2.0 m height) inside the courtyard**

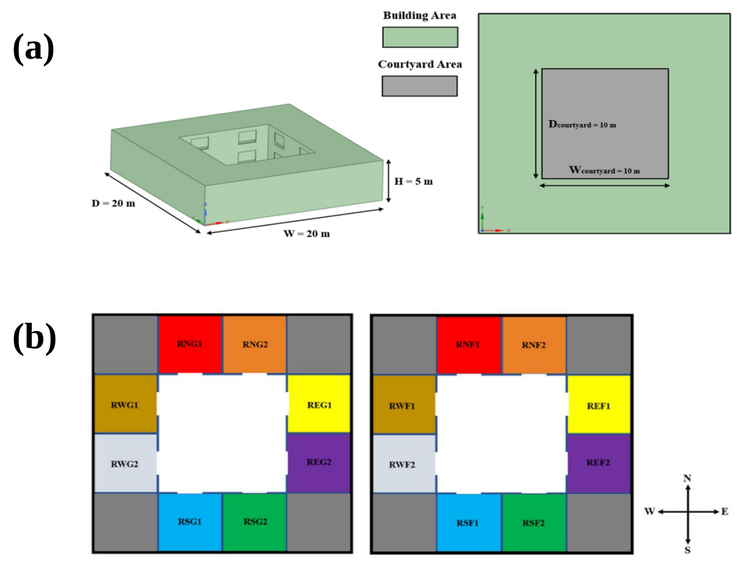


Fig 1. Courtyard model and dimensions (a), the layout of the rooms on each floor (b).

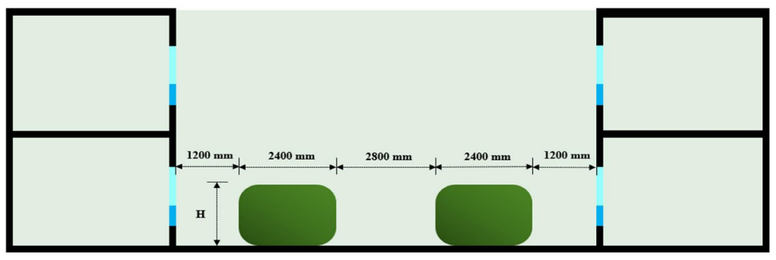


Fig 2. The dimension of the vegetation inside the courtyard model.

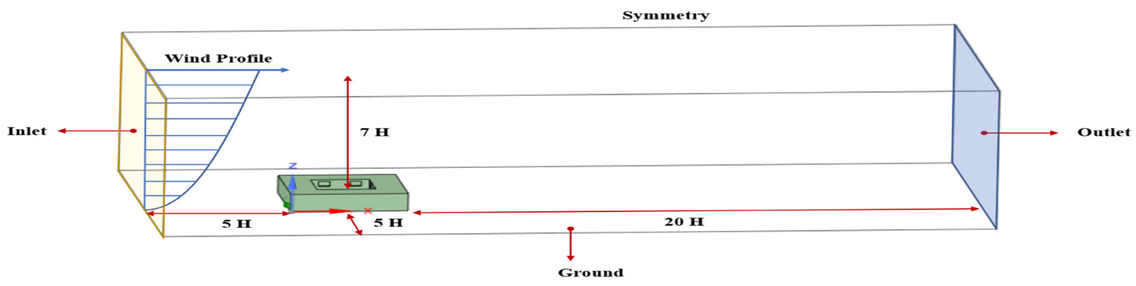


Fig 3. The dimension of the domain and the direction of the wind.

(a) **(b)**

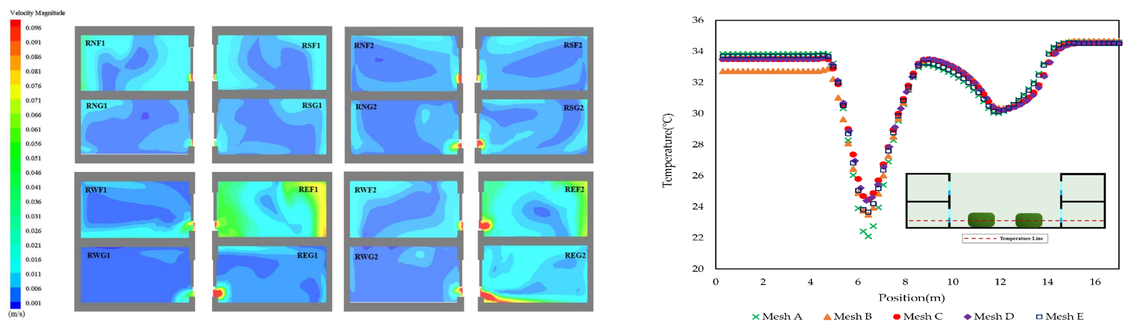


Fig 4. Airflow contours for the baseline courtyard model (a), Grid sensitivity analysis(b).

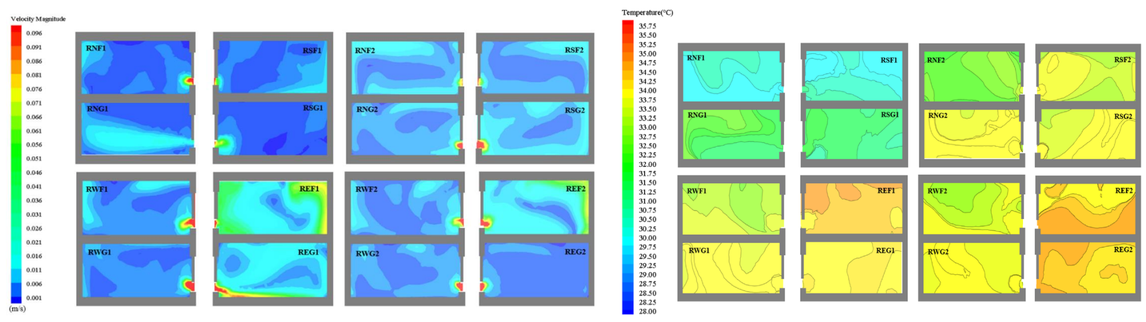


Fig 5. Airflow and temperature contours for the courtyard model with for small trees.

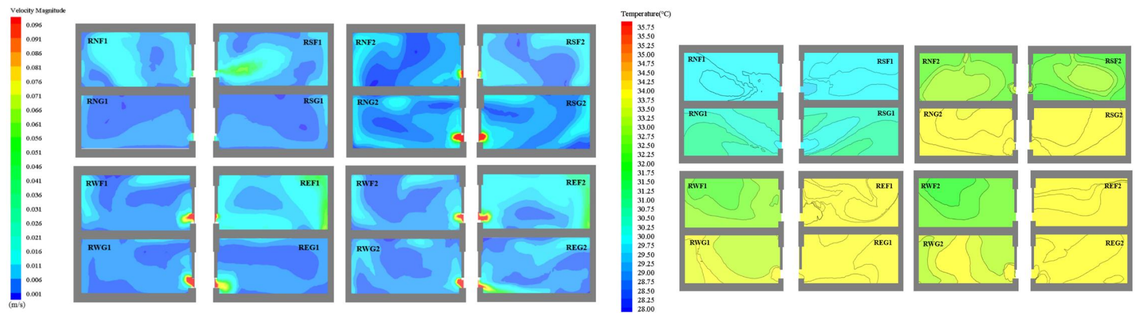


Fig 6. Airflow and temperature contours for the courtyard model with for large trees.

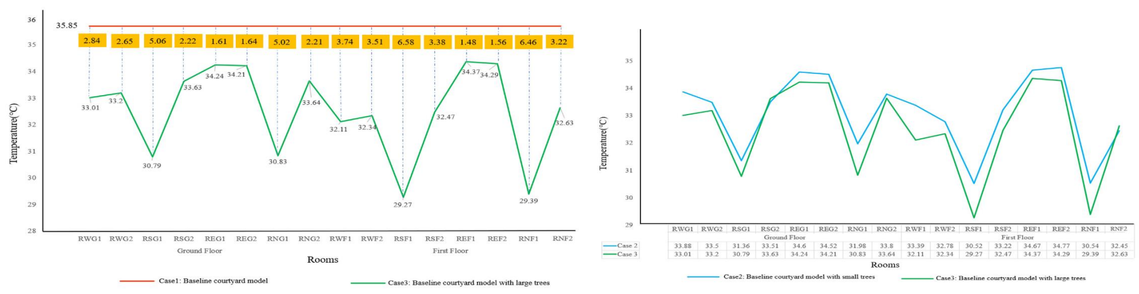
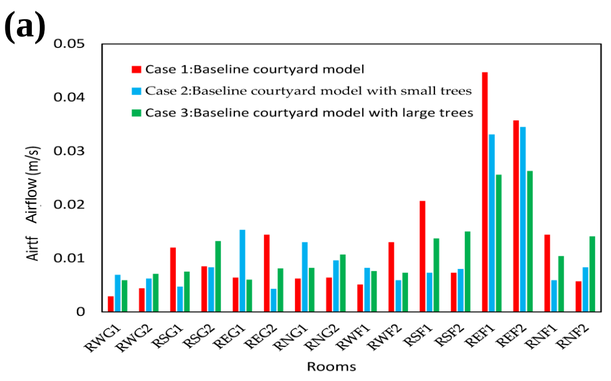


Fig 7. Comparison of temperature between three cases

(a)



(b)

Location		Indoor Thermal Comfort Index: PMV (PPD)		
		Case 1	Case 2	Case3
First Floor	RWG1	4.10 (100%)	3.35 (100%)	3.17 (99%)
	RWG2	4.10 (100%)	3.21 (100%)	3.10 (99%)
	RSG1	4.10 (100%)	2.38 (91%)	2.14 (83%)
	RSG2	4.10 (100%)	3.21 (100%)	3.26 (100%)
	REG1	4.10 (100%)	3.61 (100%)	3.48 (100%)
	REG2	4.10 (100%)	3.58 (100%)	3.47 (100%)
	RNG1	4.10 (100%)	2.63 (96%)	2.17 (84%)
	RNG2	4.10 (100%)	3.32 (100%)	3.26 (100%)
Second Floor	RWF1	4.10 (100%)	3.17 (100%)	2.68 (96%)
	RWF2	4.10 (100%)	2.94 (99%)	2.77 (97%)
	RSF1	4.10 (100%)	2.05 (79%)	1.55 (54%)
	RSF2	4.10 (100%)	3.11 (99%)	2.82 (98%)
	REF1	4.10 (100%)	3.64 (100%)	3.52 (100%)
	REF2	4.10 (100%)	3.68 (100%)	3.49 (100%)
	RNF1	4.10 (100%)	2.06 (79%)	1.60 (56%)
	RNF2	4.10 (100%)	2.81 (98%)	2.88 (98%)

Fig8. Comparison of wind speed magnitude between three cases (a)
Tab.1 Indoor thermal comfort index in each room (b)

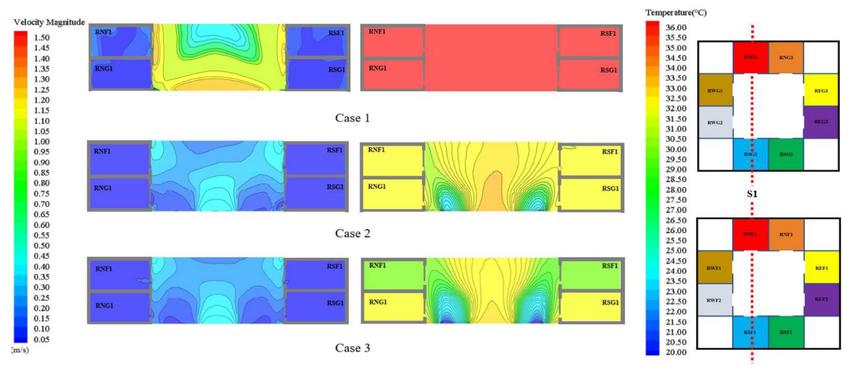


Fig 9. Contours for the wind speed magnitude and temperature within the courtyard with small and large trees

Conclusion

Vegetation has been proven to be an effective passive cooling strategy in courtyard buildings under tropical climates, significantly improving the building's thermal air performance and natural ventilation.