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Passive Cooling Design Opportunities: Lessons Learned from Traditional Banjar Houses

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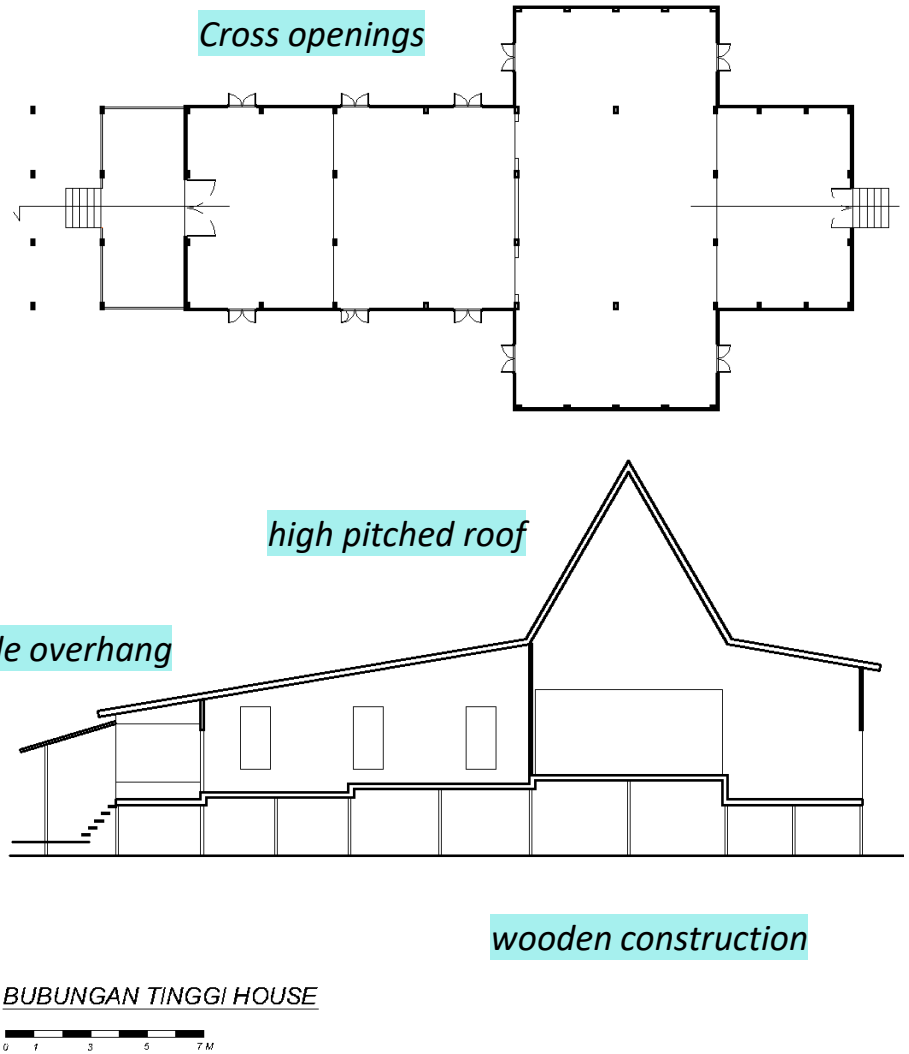
Introduction

- Passive cooling has gained significance due to climate change and energy saving.
- In terms of tropics, previous studies found that vernacular design is more responsive to their surrounding climates [1]
  - *emphasizes the adaptation to the environment, climate, culture, and social context in the development*
  - *Ventilation can increase the room temperature when unprotected and result in the entry of solar heat [2].*
  - *Even though some vernacular buildings have undergone modifications, vernacular buildings continue to survive today [3].*
- Indonesia is the largest archipelago country with thousands of ethnicities → rich in culture and vernacularity



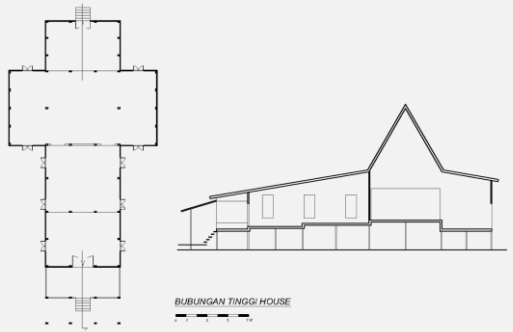
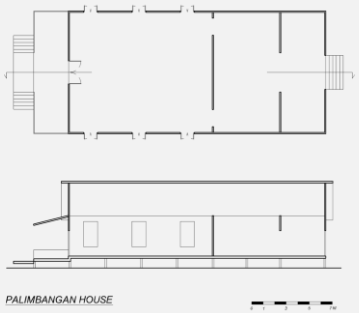
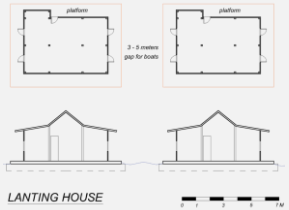
Introduction *(contd.)*

- The culture within the tribes in Kalimantan is rich and encompasses from mountainous to waterways region → Banjar vernacular architecture with the focus on three house types: Bubungan Tinggi, Palimbangan and Lanting house
- This research aims to contribute to the development of passive cooling strategies based on the local cultural heritage of the Banjar tribe, with modern technology, using CFD simulations of vernacular buildings

Method

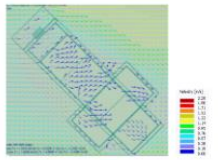
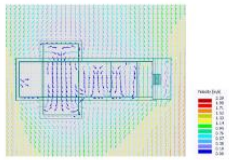
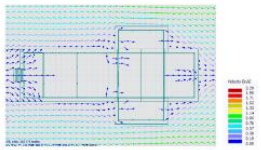
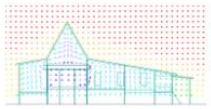
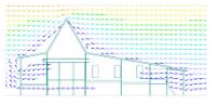
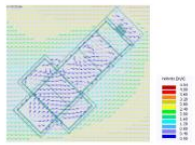
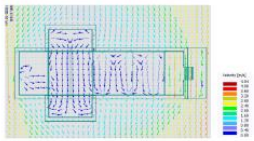
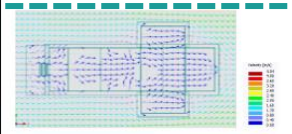
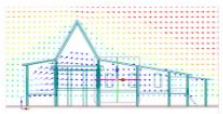
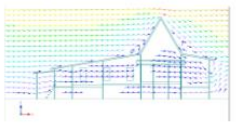
1. Literature research regarding the targeted Banjar house type, namely: (1) Bubungan Tinggi House, (2) Palimbangan House, and (3) Lanting House → regarding the width : depth proportion, and house characteristics
2. Run the simulation in RWIND dlubal CFD → parameters:
   - Two different wind speed data in Banjar → 3.5 m/s and 17 m/s
   - Three different prevailing wind directions: Diagonal, perpendicular and parallel to the depth of the house
3. The findings in each house are then being compared, to understand more regarding the effectiveness of passive cooling strategies in the implemented local wisdom from Banjar.

Result and Discussion

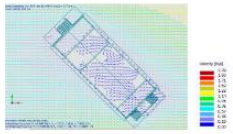
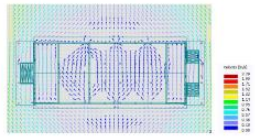
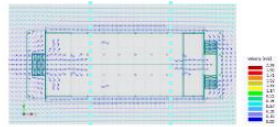
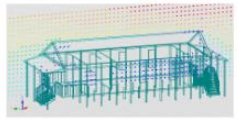
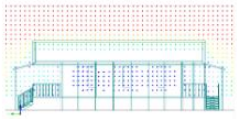
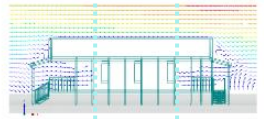
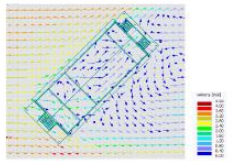
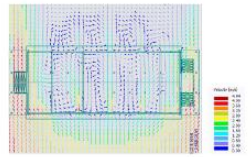
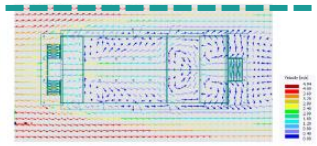
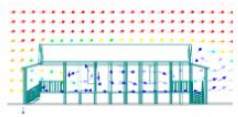
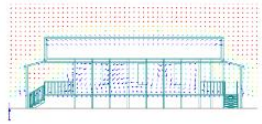
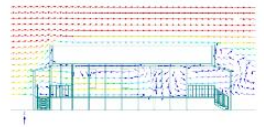
	Bubungan Tinggi	Palimbangan	Lanting
Picture			
W:D ratio	1:3 to 1:4	1:2.5 to 1:3	1:1.25
Characteristics	• Partitioned to more private area • Has a high pitched gable roof with 60^0 angles → 6 meters height	• Partitioned to more private area • Roof attic area could reach 3 metres in height • large openings makes the cross ventilation move effectively when opened, and helps the thermal performance of the building [11]	• There is a 3 to 5 metre space between the houses to park the Jukung boat [12] • rarely partitioned, and does not have a ceiling • The total height of the Lanting house is 4 metres. The roof is usually a low gable roof, with angle variation between the centre and the perimeter area of the roof.

Result and Discussion

Bubungan Tinggi House

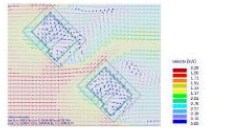
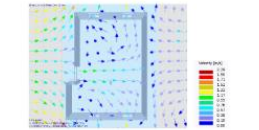
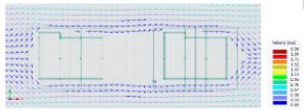
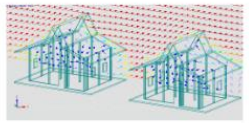
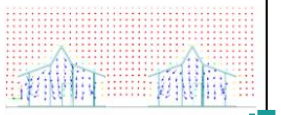
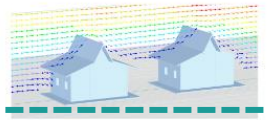
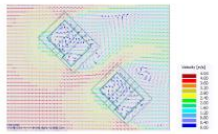
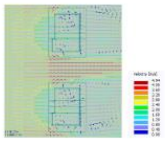
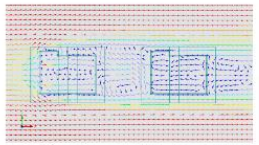
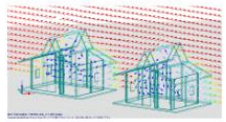
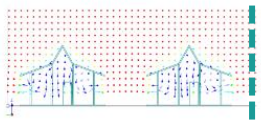
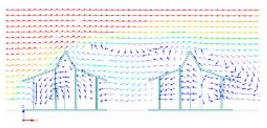
	Diagonal	Perpendicular	Parallel
Wind Speed 3.5 m/s			
			
Wind Speed 17 m/s			
			

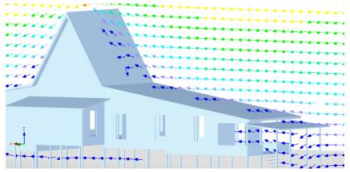
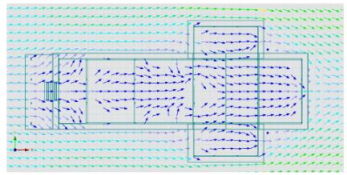
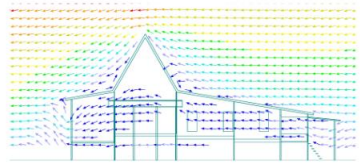
Palimbangan House

	Diagonal	Perpendicular	Parallel
Wind Speed 3.5 m/s			
			
Wind Speed 17 m/s			
			

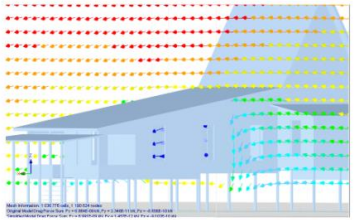
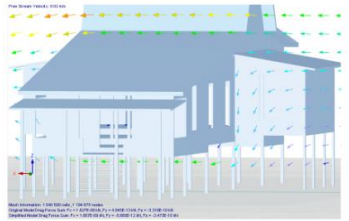
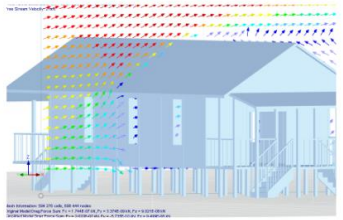
Result and Discussion

Lanting House

	Diagonal	Perpendicular	Parallel
Wind Speed 3.5 m/s			
			
Wind Speed 17 m/s			
			

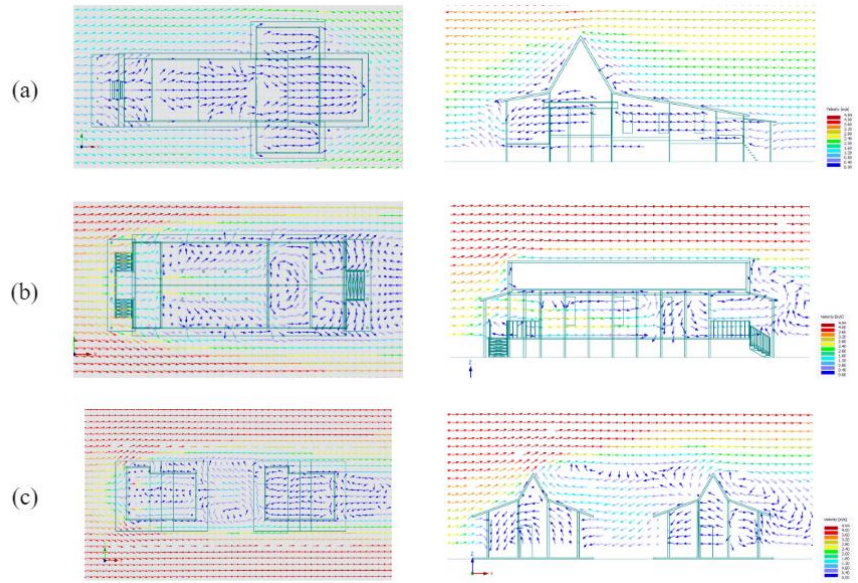




When the maximum wind speed is used for the simulation, it shows a better performance on the passive ventilation. This could be a challenge in application of the passive cooling through wind movement, as the density of the city has evolved, making the wind speed is far slower then in the past.

Kallang has created a wind streamline below the activity area → the gaps between the wooden floor panel and wooden beam configuration can serve a 'leak' outlet for the houses, that removes the humidity in the house.
Bubungan Tinggi house has a higher space of kallang than the Palimbangan house, >> the speed found in the Bubungan Tinggi's kallang is faster than the one in Palimbangan house.

- Partition in Bubungan Tinggi house cause a certain area with stagnant wind movement.
- The large back opening helps the wind to reach more area in the back area of the Palimbangan house.
- At Lanting house, the roof can direct wind movement to fill the gaps between the house.



Conclusion

- The openings design in all the house types has different effects on the wind movement throughout the building:
  - In Bubungan Tinggi house, the additional windows with different orientation ensure that the additional space that adds width to the whole building, can obtain direct fresh air from the surrounding. The partition in this house blocks the wind movement, so that the wind does not pass a certain area of the house, mostly at the back side of the house.
  - Palimbangan house has the most balanced passive cooling performance through wind movement, as the wind could reach in almost 90% area of the houses when exposed to different prevailing wind directions, even in a minimum wind speed.

→ Further research that integrates temperature in the wind movement is necessary to study the possibility of the stack effect in this certain vernacular building.

References

[1] Dhc T and T K 2015 Comparative assessment of vernacular passive cooling techniques for improving indoor thermal comfort of modern terraced houses in hot-humid climate of Malaysia Sol. Energy 114 229–58

[2] Nugroho A M 2022 Passive cooling performance on Indonesia contemporary tropical facade in producing the present comfortable space IOP Conf. Ser. Earth Environ. Sci. 1007 012005

[3] Hildegardis C, Saraswati A A A O and Dewi N K A 2019 Review of Thermal Comfort in Warm Humid Climate for Traditional Architecture in Indonesia KnE Soc. Sci. 151–67

[4] Paris M A and Wahyuda S S 2023 AKTIFITAS ETNOMATEMATIKA PADA KONSEP RUMAH ADAT BUBUNGAN TINGGI DI BANJARMASIN TAHUN 2021/2022 Educ. J. Gen. Specif. Res. 3 754–61

[5] Aqli W 2011 ANATOMI BUBUNGAN TINGGI SEBAGAI RUMAH TRADISIONAL UTAMA DALAM KELOMPOK RUMAH BANJAR NALARs 10

[6] Putro J D and Zain Z 2021 Active and passive adaptation of floating houses (Rumah Lanting) to the tides of the Melawi river in West Kalimantan, Indonesia Geogr. Pannonica 25 72–84

[7] Putro J D and Zain Z 2021 Space Setting Process in Floating Houses (Rumah Lanting) IOP Conf. Ser. Earth Environ. Sci. 764 012004

[8] Sarkar A and Bardhan R 2020 Improved indoor environment through optimised ventilator and furniture positioning: A case of slum rehabilitation housing, Mumbai, India Front. Archit. Res. 9 350–69

[9] Anon BPS Kota Banjarmasin

[10] Zohrah L and FUKUKAWA Y 2010 CHARACTERISTICS OF TRADITIONAL HIGH RIDGE HOUSES IN BANJARESE KAMPUNGS, SOUTH KALIMANTAN, INDONESIA J. Archit. Plan. Trans. Aij 75 149–56

[11] Mutmainah S, Rifkah G S and Razaki H 2019 KUALITAS KENYAMANAN TERMAL RUMAH PALIMBANGAN DI SUNGAI JINGAH J. Arsit. Mns. Dan Lingkung. Jamang 1 080–4

[12] Afdholy A R 2017 “RUMAH LANTING” Arsitektur Vernakular Suku Banjar Yang Mulai Punah Local Wisdom J. Ilm. Kaji. Kearifan Lokal 9 103–17

[13] Bhatia A HVAC - Natural Ventilation Principles and Practices www.cedengineering.com