2nd Biennial of Tropical Architecture of Reunion Island
9th -12th November, 2022

Bio-climatic design as a solution for residential building thermal comfort in tropical climate

Kimnenh TAING – Double degree PhD at University of Liege and Institute of Technology of Cambodia - kimnenh.taing@doct.uliege.be

Context

Vernacular or traditional houses in tropical region is mostly build with timber and on stilt. This type of architecture has been responding so well to climate context of this region and have been practiced till today for some part of country. In the past decade, with changing of climate and the advancement of technology, material such as brick and glass has become the main material for building construction in this region and less and less houses are built on stilt. Social cultural and people's lifestyle has impact on the design of building that focus more on aesthetic and budget of construction than a building that provide a comfort in this intense temperature [1]. With all these new changes, new design of building has been appeared. However, the question of comfort and the energy consumption of these new design building has been rising a lot especially for the region with high intense temperature such as tropical climate.

Objective and Research Statement

The objective of our research is to analyze the thermal performance of new design residential building and to find a suitable solution that is environmental friendly to this problem.

1. What is the thermal performance of current residential building in Phnom Penh?
2. What are the most important factors that make occupant satisfied with building thermal performance?
3. What the most environmental solution to the thermal performance in the tropical region?

"a regionalist architectural design based on the use of quantitative data related such as climatic data and human comfort requirements" [2]

What is Bio-climatic design?

"a design method that focus on human friendly, eco-friendly and energy friendly" [3]

Conclusion

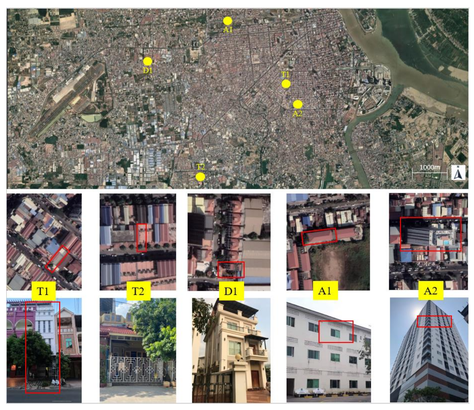
The new material and the new design in the past decade don't respond to the transition of climate at all. The interview and survey lead us to compare PMV (Post Mean Vote) and PPD (Predicted Percentage of Dissatisfaction) [4] which show that people in tropical climate region prefer a slight colder temperature than the PPD scale in order for them to feel satisfy. As it turns out that air velocity plays an important role in comforting the occupant, the design of the houses therefore should focus not only on sunlight protection but more on the design that allow ventilation flow.

Future study

The first step of the study to answer to our research question is completed and with this finding we intend to apply the design concept that respond to the climate condition itself. Implementation Bioclimatic concept in designing housing in tropical region is an answer to our question and the next step that we want to study and evaluate. With the data of thermal performance of building, we can do simulation with the application of bioclimatic design and see if it helps the building to respond better to the transition of climate in this region.

Methodology

Case Study Building (Phnom Penh, Cambodia)



→ In-situ Measurement
AT, RH – Data Logger
AV- Hot-wire anemometer
(01/Apr – 01/May, 25/Jun – 05/Aug, 2021)

→ Occupant Survey and Interview
ASHRAE Base Questionnaire

} Completed

↓

Digital Model – Simulation (In progress)

↓

BIM Model → Thermal Performance Analysis → Energy Performance Analysis → Evaluation of Bioclimatic Design Strategies

Result

❖ The result that we received which will be published in January in IOP Conference: Earth and Environment Series show that:

- During both dry and rainy seasons the temperature in all case study buildings is 1 to 3 °C higher than the acceptable standard temperature in tropical regions.
- Air velocity appears as a factor that highly contributes to the comfort of occupant.
- Detached House (D) which has the most similar design to the traditional house and the best airflow turn out to have the best thermal performance

❖ The answers from the survey and questionnaire allow to know about their sensation (PMV) and satisfaction to thermal performance of theirs house and identify their preference to feel comfort.

Table 1: PMV and PPD of occupant living in house T1

TA (°C)	RH (%)	PMV	PPD (%)	TA (°C)	RH (%)	PMV	PPD (%)
31	69.5	1	30	32.5	62.5	2	0
31	68	1	30	31	68.5	-2	85
31.5	66	1	50	32	67	0	50
32	61	-1	70	31	71.5	-2	85
32	70	3	0	32	67.5	0	50
31.5	67.5	-1	70	31	72	-1	70
31	67	-1	70	31	72	-1	70
32	67	0	50	30	65	-2	85

TA : Air Temperature
RH : Relative Humidity
PMV : Predicted Mean Vote
PPD : Predicted Percentage of Dissatisfied (100% = Very Satisfied)
PMV Scale : -3 to 3 (very cold to very hot)

Bibliography

[1] T. Kubota, H. B. Rijal, and H. Takaguchi, "Sustainable houses and living in the hot-humid climates of Asia," Sustain. Houses Living Hot-Humid Clim. Asia, pp. 1–559, 2018, doi: 10.1007/978-981-10-8465-2.
[2] V. Olgyay, "Design with climate: Bioclimatic approach to architectural regionalism: New and expanded edition," Design with Climate: Bioclimatic Approach to Architectural Regionalism: New and Expanded Edition. pp. 1–190, 1963.
[3] D. L. Zr and S. Mochtar, "Application of Bioclimatic Parameter as Sustainability Approach on Multi-story Building Design in Tropical Area," Procedia Environ. Sci., vol. 17, pp. 822–830, 2013, doi: 10.1016/j.proenv.2013.02.100.
[4] J. Van Hoof, "Forty years of Fanger's model of thermal comfort: Comfort for all?," Indoor Air, vol. 18, no.3, pp. 182–201, 2008, doi: 10.1111/j.1600-0668.2007.00516.x.