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Optimization of Thermal Comfort Through Analysis of Passive Design Strategies in Memarong Nok and Memarong Mak Traditional Buildings

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ABSTRACT
The issues of global warming and rising environmental temperatures require a building design approach that can optimize thermal comfort without relying on active cooling systems. Vernacular architecture offers passive design principles based on local wisdom that are adaptive to the climate. This study aims to analyze the application of passive design strategies in the Memarong Nok and Memarong Mak Traditional Buildings in the Gebong Memarong Traditional Village, Mapur Village, Bangka Regency, as a basis for the development of sustainable vernacular architecture. This study employs a mixed-method approach integrating qualitative and quantitative strategies. Qualitative data were obtained through field observations to understand the spatial characteristics and passive design strategies of the building, while quantitative data were collected through on-site measurements of air temperature, relative humidity, wind speed, and solar radiation during peak daytime heat conditions. Thermal comfort analysis was conducted using the adaptive thermal comfort model based on ASHRAE Standard 55 and supported by Thermal Humidity Index (THI) calculations to quantitatively assess the building's environmental performance. The results of the study show that both buildings are able to achieve thermal comfort conditions at outside temperatures of up to 32°C, with Memarong Nok in the comfortable category (THI 24.0°C) and Memarong Mak in the moderately comfortable category (THI 24.8°C). However, at more extreme outside temperatures, the thermal performance of the buildings declines. These findings confirm that passive design elements such as natural ventilation, the use of lightweight natural materials, building orientation, roof shape, and overhangs play a significant role in controlling heat and humidity. This study concludes that passive design principles based on local wisdom are still relevant and have the potential to be adapted as a sustainable building design strategy that is responsive to today's tropical climate.
Keywords: *Gebong Memarong; Thermal Comfort; Passive Design Strategies; Vernacular*

INTRODUCTION

Global warming has consistently been recognized as one of the most pressing global challenges due to its widespread environmental, social, and economic impacts. The rising global average temperature, largely driven by greenhouse gas emissions, has intensified climate change impacts. This condition increases urban heat island effects, cooling energy demand, and thermal discomfort, particularly in tropical regions, underscoring the need for adaptive and climate-responsive design strategies (Chan & Chau, 2021; Santi et al., 2019). Various efforts need to be made to solve this problem. One of the causes of the significant increase in the Earth's average temperature is greenhouse gas emissions. One sector that contributes greatly to the increase in carbon emissions and the greenhouse effect is the construction and building sector, which accounts for about 30% of total global energy consumption (Khan et al., 2025; Zheng, 2024).

Good design efforts play an important role in addressing global warming issues, reducing adverse environmental impacts, optimizing thermal comfort, and reducing energy consumption (Krištofič et al., 2025). Some steps that can be taken include applying passive concepts, namely design strategies that rely on elements of the building itself, such as ventilation, building materials, building orientation, roof shape, walls, and overhangs (Winandari et al., 2023). This strategy is considered capable of creating a comfortable space (Cheng et al., 2023; Ulinata et al., 2023), minimizing environmental impact, saving energy and resources more efficiently, ("Innovative Aspects Of Energy Resources Saving And Energy Efficiency," 2021) and preventing heat from escaping through the building (Baniassadi et al., 2019; Venckus et al., 2012).

Traditional villages are a form of cultural heritage that represent local wisdom in architecture and spatial planning. Traditional architectural values reflected through building elements and systems demonstrate indigenous principles that are adaptive to the environment. Therefore, the application of traditional architectural elements is still relevant today, as some of these systems have proven effective in creating comfortable and sustainable buildings. Thus, local cultural heritage can serve as a foundation for the development of sustainable architecture in the future. However, studies on passive concepts in traditional villages are still very limited. Several review studies on vernacular architecture indicate that, although the field has been widely explored, comprehensive investigations focusing on passive environmental strategies remain limited and require further development (Moscoso-García & Quesada-Molina, 2023). Literature on traditional houses in Indonesia emphasizes that studies on passive cooling are still relatively scarce and have not optimally linked design strategies with specific local contexts (Angkasa & Kamil, 2024). Other studies also reveal a knowledge gap in the investigation of passive design strategies in tropical vernacular housing (Salimi et al., 2025). In Bangka Belitung, there is a vernacular building whose facade and construction use natural materials and implement passive ventilation strategies to optimize thermal comfort. This building is located in the traditional village of Mapur, Bangka Regency, called Gebong Memarong.

Vernacular buildings are the result of a long process of development and have been passed down from generation to generation. Their form and system were developed as a result of adaptation to physical environmental conditions such as climate, wind direction, sunlight intensity, temperature, and humidity, as well as the socio-cultural environment of the local community (O'Malley et al., 2014). Residents adapt their lifestyles and housing designs by utilizing the natural potential of their surroundings, such as cooling winds, shade from trees, and locally sourced natural materials. At the same time, they also strive to minimize factors that can interfere with the comfort of their homes, such as excessive heat, high rainfall, and humidity levels(Vinky Rahman & Luqman Hadi Wibowo, 2021).

The application of passive design concepts in vernacular buildings can form the basis for the development of sustainable architecture today. Historically, vernacular buildings have been able to adapt to local environmental conditions, particularly in maintaining thermal comfort through design strategies that are responsive to the climate. However, with the emergence of global environmental issues such as global warming and the increasing phenomenon of urban heat islands (UHI)(Chan & Chau, 2021; Karimi et al., 2020). As a result, there is a noticeable difference in temperature between urban areas and surrounding areas. This UHI phenomenon will certainly affect the quality of the outdoor thermal environment (Yan & Dong, 2015). This raises the critical question of the extent to which passive design principles in vernacular buildings are still relevant and effective for application in today's modern environmental context.

Based on these issues, this study aims to analyze the application of passive design strategies in Gebong Memarong traditional buildings. This analysis is conducted to examine indigenous principles that are adaptive to the environment as a basis for the development of sustainable vernacular buildings. In addition, this study is also intended as a step to optimize the application of passive design strategies amid the increasing issues of global warming and the increasingly

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significant phenomenon of urban heat islands (UHI) in the context of contemporary architecture.

LITERATURE REVIEW

A. Passive Design Strategies

Passive design strategies are architectural planning approaches that focus on utilizing the natural conditions and potential surrounding a building to achieve optimal thermal comfort. This approach is implemented through the arrangement of the building's physical characteristics, which involves various design components, such as building orientation, building envelope configuration, the use of shading elements, and the integration of other architectural components attached to the façade (Altan et al., 2016; Simbolon & Nasution, 2017). Passive design strategies play a role in creating spatial comfort (Alam et al., 2014; Sun et al., 2018), but also contribute to reducing environmental impact through efficient use of energy and resources (Hoyle, 2011; Putra, 2016; Simbolon & Nasution, 2017).

In buildings located in tropical climates, the application of passive design principles is very important because it can control temperature increases in rooms through the determination of the correct building orientation, the provision of shade on walls and openings, the use of thermal mass, the use of light-reflective surfaces, and the regulation of natural ventilation. Thus, passive design serves as a strategic solution in creating energy-efficient buildings. Several passive design components that have been proven to significantly reduce energy consumption include building orientation, window-to-wall ratio (WWR), natural ventilation systems, glass type and performance, overhang dimensions and configuration, wall materials, and roof design (Abbakyari & Taki, 2017; Ahady et al., 2019; Bano & Sehgal, 2018; Kesavaperumal & Selvaraj, 2014; Lan et al., 2019; Latief et al., 2016; M. Al-Tamimi et al., 2011).

B. Thermal Comfort

Thermal comfort is a condition in which humans feel satisfied with their thermal environment, commonly referred to as thermal sensation. The term thermal sensation refers to the subjective perception of heat or cold that arises as a physiological response of the skin and sensory system to environmental temperature. There are four variables that must be considered in thermal comfort, namely: (1) Air temperature (2) Average radiant temperature, (3) Wind speed, (4) Air humidity. Thermal comfort calculations can also refer to the Thermal Humidity Index. (Karimi et al., 2020; Ramawangsa, 2021; Rosyidy et al., 2020; Wati & Fatkhuroyan, 2017). The Thermal Humidity Index (THI) formula is a :

$$\mathbf{THI = 0{,}8\ T + (RH \times T) / 500}$$

THI : Temperature Humidity Index
T : Temperature (C)
RH : Relative Humidity (%)

The THI value ranges commonly used in climatology and thermal comfort studies. These categories are used as a reference in determining whether the thermal environment is very comfortable, comfortable, moderately comfortable, or uncomfortable.

Table 1. Comfort category based on THI value

THI Value	Comfort category
< 21^0C	Very comfortable
21 – 24^0C	Comfortable (100% of the population feels comfortable)
24 – 27^0C	Fairly comfortable (50% of the population feels comfortable)
>27^0C	Uncomfortable (100% of the population feels uncomfortable)

Source: Energy Report & Jurnal Meteorologi Klimatologi Dan Geofisika (Karimi et al., 2020a; Rosyidy et al., 2020)

RESEARCH METHODS

This study uses a descriptive qualitative method. A qualitative research approach is used to explore and understand the meanings that emerge from individual experiences and social phenomena related to a humanitarian issue (Creswell, 2014). The analysis process in this study began with the collection of secondary data related to passive design strategies and the Thermal Humidity Index (THI). Primary data was obtained through field observations and direct measurements to identify the physical elements and factors of the building. Next, a descriptive analysis was conducted to examine the relationship between the thermal conditions of the building and the application of physical elements in traditional buildings. The results of this analysis were then processed into a formulation of passive design strategies that are adaptive to thermal environmental conditions, both inside and outside the building.

A. Data Collection Method

Field measurements were conducted at a specific time period representing peak daytime thermal conditions. The measurements were taken at 1:00 p.m., as secondary climate data obtained from Meteoblue indicate that the highest daily air temperatures in Bangka Belitung generally occur around this hour (see Figure 1). Therefore, this time was selected to capture representative maximum thermal exposure conditions during the day.

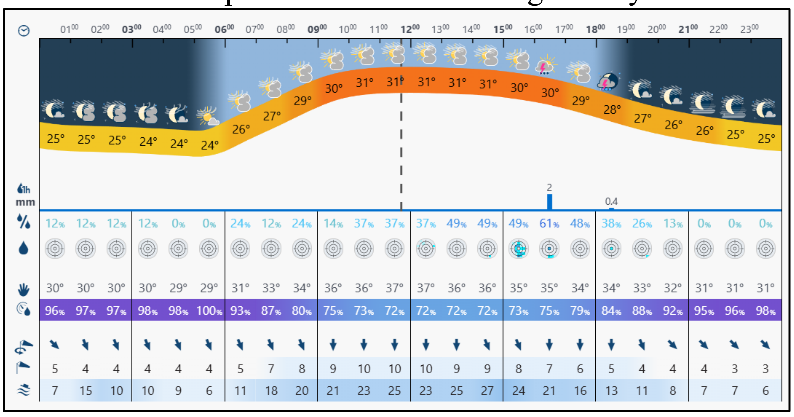

Figure 2. Hourly weather Pangkalpinang
Source: Meteoblue.com

Field measurements were conducted within a specific time frame, namely when thermal conditions reached their peak during the day. Data collection was scheduled for 1:00 p.m. because, based on climatological data for the Bangka Belitung region, this period represents the peak of daily heat intensity, when solar radiation is at its maximum and air temperature reaches its highest value. This time was chosen to obtain a representation of the most extreme thermal conditions, so that the measurement results could accurately describe the performance of building elements in responding to environmental heat. The measurement process was carried

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out by observing the parameters of air temperature, relative humidity, and the physical characteristics of the building at that time (see Figure 2).

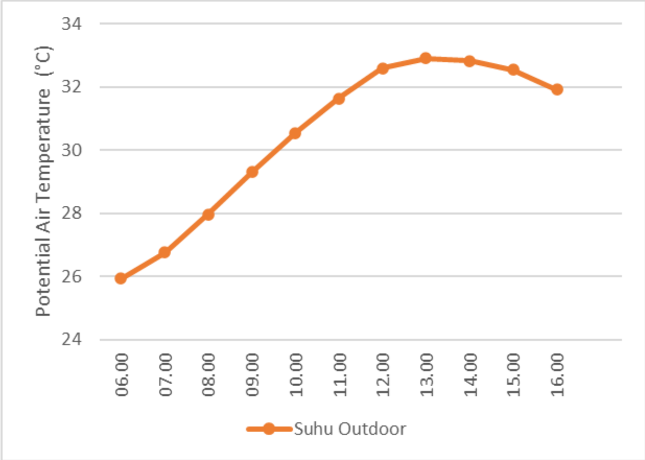

Figure 2. Outdoor Temperature Conditions
Source: Analysis (2025)

The research was conducted in the traditional village of Gebong Memarong. The traditional village of Gebong Memarong is located in Air Abik Hamlet, Mapur Village, Belinyu Subdistrict, Bangka Belitung Islands Province. (Direktorat Kepercayaan Terhadap Tuhan Yang Maha Esa dan Masyarakat Adat. Direktorat Pendidikan Kebudayaan. Kementerian Pendidikan Kebudayaan Riset dan Teknologi, 2022). The following is an aerial view of Gebong Traditional Village taken using a drone. The village consists of seven buildings of three types: Memarong Mak, Memarong Nuk, and Balai Adat (see Figure 2). The buildings that will be used as case studies are Memarong Mak and Memarong Nok.

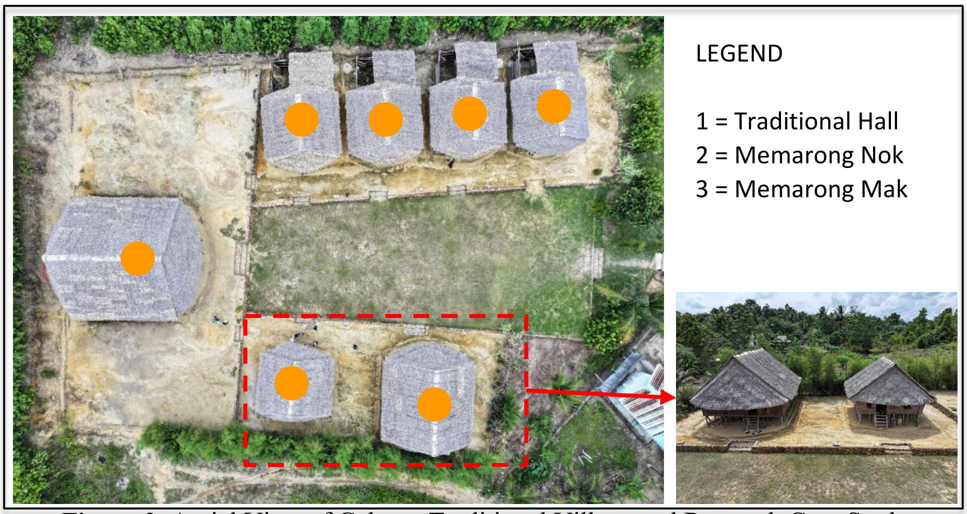

Figure 2. Aerial View of Gebong Traditional Village and Research Case Study
Source: Analysis (2025)

Data collection uses primary and secondary collection methods. Primary data collection is carried out by collecting building material data, measuring buildings, measuring humidity, temperature and wind currents, and radiation entering and outside the building. The tools used were a temperature and humidity meter, an anemometer, a solar power radiation meter, and a laser meter. This primary data was then used to analyze the thermal conditions of the external environment and the Memarong Mak and Memarong Nok buildings. In addition, an analysis was conducted on the application of passive design strategies in the traditional Gebong Memarong building, which formed the basis for the development of a sustainable vernacular architectural concept that is adaptive to the environment. Meanwhile, secondary data collection was carried out through interviews with the Traditional Leader and the manager of Kampung Gedong Memarong to obtain additional information related to the social, cultural, and functional context of the building.

B. Data Analysis Method

The data analysis method obtained from the results of observations and measurements is in the form of documentation and building measurement records. In addition, thermal data measurements on buildings are also analyzed. Thus, the data to be analyzed through observation and measurement is divided into two categories, namely physical factor data and physical element data. Physical factor data consists of air temperature, humidity, wind speed, and radiation. Meanwhile, physical element data consists of ventilation, building materials, building orientation, roof shape, walls, and building overhangs.

The data was then analyzed using descriptive analysis methods to present a more comprehensive analysis of the influence and relationship between physical factors and physical elements of a building in creating thermal comfort. The steps are:

1. Observing which buildings to select for writing.
2. Measuring temperature using a thermometer, measuring humidity using a thermohygrometer, measuring wind speed using an anemometer, and measuring radiation using a solar power meter.
3. Observing and documenting the physical elements of the building.
4. Conducting a descriptive analysis of the influence of the relationship between physical elements and physical factors of the building.
5. Reviewing recommendations for adaptive passive design strategies as a basis for the development of sustainable vernacular buildings.

RESULTS AND DISCUSSION

A. Thermal Comfort

Based on the concept of thermal comfort described above, evaluating the thermal conditions of traditional buildings is an important step in understanding the extent to which buildings can provide comfort to their occupants. Therefore, an analysis was conducted on two types of traditional buildings, namely the Memarong Nok Traditional Building and the Memarong Mak Traditional Building, to determine their thermal performance using the CBE Thermal Comfort Tool approach based on the ASHRAE 55 standard and the Thermal Humidity Index (THI) calculation. This analysis was conducted to identify the level of thermal comfort in both shaded and hot conditions as a basis for formulating passive design strategies that are in line with the character of the building and the local climate.

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1. Thermal Conditions in Memarong Nok Traditional Buildings

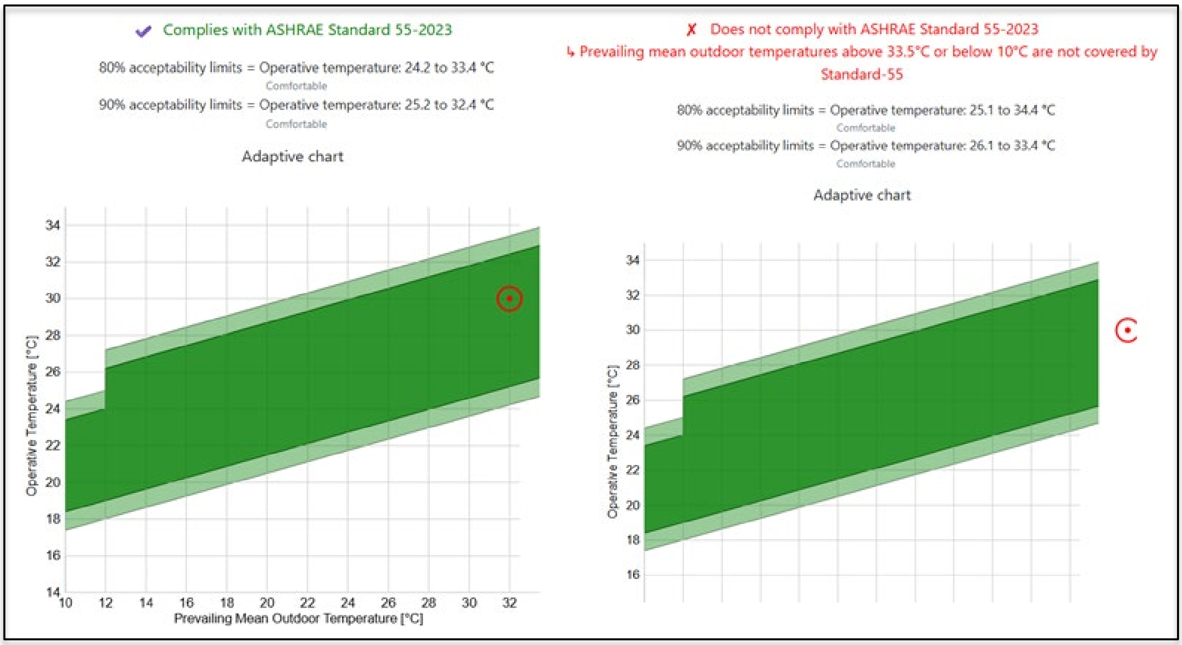

Figure 3. Simulation results with an outside temperature of 32°C (left) and Simulation results with an outside temperature of 35°C (right)
Source: Analysis (2025)

Based on the simulation results using the CBE Thermal Comfort Tool with reference to ASHRAE Standard 55-2023, with an indoor operative temperature of 30°C, while the prevailing mean outdoor temperature is in the range of 32–35°C. The simulation results show that when the outdoor temperature is 32°C, the measurement data point is in the green zone on the adaptive comfort graph. This indicates that the thermal conditions inside the Memarong Nok Traditional Building are still within the comfort limits, with an occupant acceptance rate of 80–90%, in accordance with the adaptive thermal comfort criteria for tropical climates.

However, when the outside temperature rises to 35°C, the measurement point moves outside the green zone, which means that the conditions no longer meet the thermal comfort standards based on ASHRAE 55. Thus, it can be concluded that in high outside temperature conditions, the outdoor space around the building and unprotected areas begin to experience thermal discomfort due to increased radiation temperatures and low natural air velocity entering the interior space. This phenomenon shows that the thermal performance of the Memarong Nok Traditional Building is still influenced by the surrounding environmental temperature, especially during the day when temperatures reach their highest point. When the outside temperature rises to 35°C, the thermal condition point of the space shifts out of the ASHRAE 55-2023 adaptive comfort zone. This shift indicates that the Memarong Nok traditional building's ability to maintain thermal comfort begins to decline under extreme climatic conditions. Although occupants can still adaptively tolerate certain temperature fluctuations, the simulation results show that at such high outside temperatures, existing passive design mechanisms such as natural ventilation and thermal mass are no longer able to optimally offset the environmental heat load.

This phenomenon confirms that the thermal performance of buildings is greatly influenced by the interaction between the surrounding microclimate conditions and the characteristics of the building envelope. At high outdoor temperatures, increased heat radiation and heat accumulation in building elements cause a significant increase in room operating temperature. This condition is exacerbated by increased hot wind speeds entering the interior, so that instead of functioning as cooling, natural ventilation has the potential to bring additional heat into the building.

2. Thermal Conditions in Memarong Mak Tradiotional Buildings

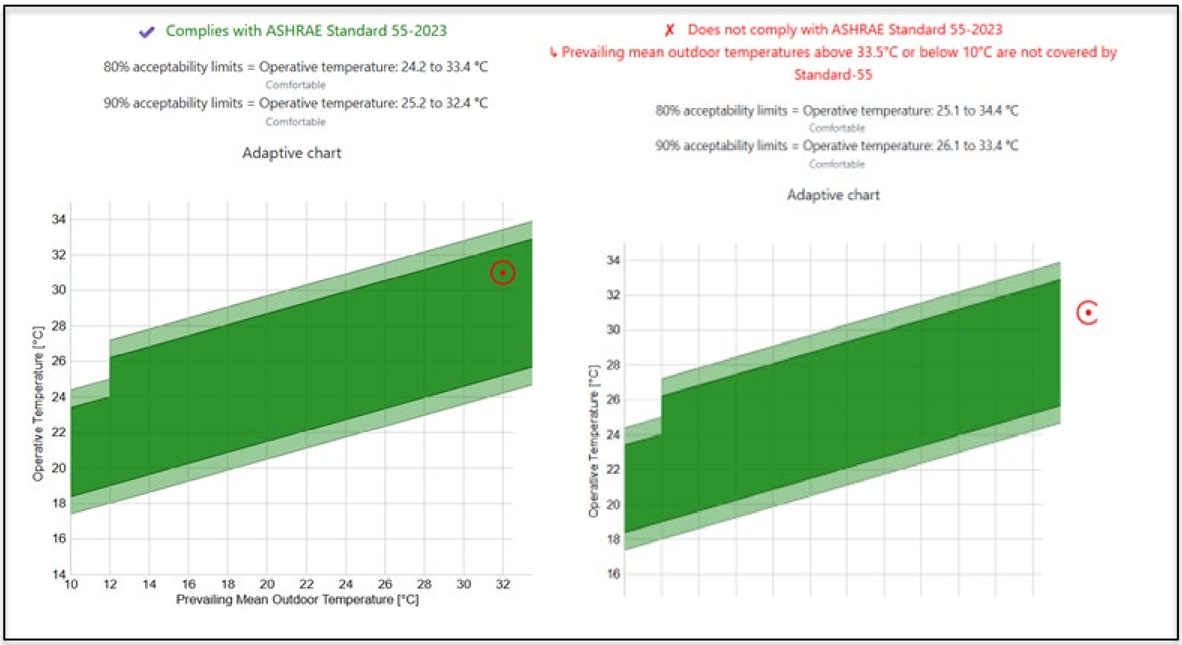

Figure 4. Simulation results with an outside temperature of 32°C (left) and Simulation results with an outside temperature of 35°C (right)
Source: Analysis (2025)

This phenomenon confirms that the thermal performance of buildings is greatly influenced by the interaction between the surrounding microclimate conditions and the characteristics of the building envelope. At high outdoor temperatures, increased heat radiation and accumulation Simulation results of thermal conditions in the Memarong Mak Traditional Building show a similar pattern. However, with an indoor temperature 1°C higher at 31°C and an outdoor temperature in the range of 32–35°C. The adaptive comfort graph shows that at an outdoor temperature of 32°C, the measurement point is still within the green zone. This condition indicates that the interior space can still be categorized as comfortable based on ASHRAE 55 standards, with a level of comfort that is acceptable to most users of the space. However, when the outside temperature increases to 35°C, the measurement point shifts out of the comfort zone, indicating that both the exterior space and the semi-protected areas around the building begin to experience thermal discomfort. This condition occurs due to an increase in radiation temperature and a decrease in the ability of natural ventilation to lower the room temperature. Heat accumulation in building elements causes a significant increase in the operative temperature of the room. This condition is exacerbated by the increased speed of hot wind entering the interior space, so that instead of functioning as cooling, natural ventilation has the potential to bring additional heat into the building.

Comparatively, these findings also indicate that both Memarong Nok and Memarong Mak have relatively similar thermal performance thresholds, which are effective up to outdoor temperatures approaching 32°C. Above this threshold, thermal comfort levels begin to decline significantly. Therefore, additional passive design strategies need to be optimized, such as

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increasing shading elements, more adaptive opening control, and selecting materials with better heat capacity and reflectance to improve the building's thermal resistance to climate variability. In general, both traditional buildings show that thermal comfort can be achieved when the outside temperature does not exceed 32°C. Above this temperature, both Memarong Nok and Memarong Mak tend to experience a decline in thermal comfort, especially in outdoor areas and rooms that are not directly protected from solar radiation.

Thus, the results of this analysis not only confirm the limitations of thermal comfort in high temperature conditions, but also provide a scientific basis for the development of passive design approaches that integrate vernacular architectural principles with passive technology. This approach is becoming increasingly relevant in the face of rising environmental temperatures due to climate change, particularly in traditional buildings in tropical regions.

3. Thermal Humidity Index (THI)

Thermal comfort calculations can also refer to the Thermal Humidity Index. (Karimi et al., 2020a; Ramawangsa, 2021; Rosyidy et al., 2020; Wati & Fatkhuroyan, 2017). The Thermal Humidity Index (THI) is used as an additional indicator to assess the level of thermal comfort in the Memarong Nok and Memarong Mak Traditional Buildings. This index combines the effects of air temperature and relative humidity to provide a more comprehensive picture of the occupants' perception of comfort.

Based on THI values, further analysis was conducted by calculating the THI value from the temperature and humidity measurements in both traditional buildings. This calculation aimed to identify the actual level of comfort felt by occupants under existing conditions. To compare the comfort levels of the two buildings, the calculated THI values are presented in Table 2. This presentation allows for a direct evaluation of the differences in thermal comfort performance between Memarong Nok and Memarong Mak. The results in Table 2 show that the Memarong Nok Traditional Building is in the comfortable category, while Memarong Mak is in the moderately comfortable category. This difference indicates variations in natural ventilation performance and building envelope capacity in controlling indoor temperatures. Overall, the THI analysis reinforces previous findings that both buildings are still capable of providing thermal comfort under certain conditions, although comfort levels decrease when the outside temperature rises above 32°C.

Table 2. Comfort category in case study buildings

Buildings	THI Value	Comfort category
Memarong Nok	24.0	Comfortable
Memarong Mak	24.8	Fairly comfortable

Source: Analysis (2025)

The calculation results show that the Memarong Nok Traditional Building has a THI value of 24.0°C, which is within the range of 21–24°C and is categorized as comfortable. Meanwhile, the Memarong Mak Traditional Building shows a THI value of 24.8°C, which is in the range of 24–27°C and is classified as moderately comfortable, with a level of comfort that is statistically felt by around 50% of the population. The 0.8°C difference in THI between the two buildings, although relatively small numerically, has significant implications for the thermal comfort performance of the buildings. The lower THI value at Memarong Nok indicates the building's ability to control increases in internal air temperature and humidity more effectively than Memarong Mak. This condition leads to the assumption that the passive design strategies applied to Memarong Nok, such as the effectiveness of cross ventilation, the orientation of the building towards the dominant wind direction, and the configuration of openings, function more optimally in supporting heat release and natural air circulation.

Conversely, the THI value approaching the upper comfort limit at Memarong Mak (24.8°C) indicates that this building is in a transitional state towards thermal discomfort. This indicates limitations in the performance of the building envelope or natural ventilation system in responding to outdoor climate conditions, especially when the outdoor air temperature rises above 32°C. Thus, although Memarong Mak is still able to maintain relatively acceptable thermal conditions, the effectiveness of its passive design strategy tends to be lower than that of Memarong Nok.

Overall, the results of this THI analysis reinforce the findings that both traditional buildings are still capable of providing thermal comfort without the aid of active cooling systems, but with different levels of performance. Memarong Nok shows a better level of thermal adaptation to the tropical climate, while Memarong Mak requires further optimization in terms of passive design, particularly in improving air flow and internal heat control. These findings confirm that differences in the application of passive design strategies in traditional buildings play a crucial role in determining the level of thermal comfort, and are an important basis for efforts to optimize sustainable building design based on local wisdom.

B. The Relationship between Passive Design Strategies in Memarong Nuk and Memarong Mak Traditional Buildings Due to Thermal Comfort of Interior Spaces

Based on the analysis results, the Memarong Nok and Memarong Mak Traditional Buildings are generally categorized as comfortable to moderately comfortable. The results of adaptive thermal comfort simulations based on ASHRAE Standard 55 show that indoor conditions remain within the comfort zone at outdoor temperatures of up to 32°C, supported by Thermal Humidity Index (THI) values that are classified as comfortable for Memarong Nok (24.0°C) and reasonably comfortable for Memarong Mak (24.8°C). These findings demonstrate the adaptive ability of both buildings in responding to the humid tropical climate without a mechanical air conditioning system. This level of thermal comfort indicates the significant role of passive design strategies in controlling indoor thermal conditions. Therefore, this subsection focuses on analyzing the relationship between physical elements of buildings, such as ventilation, materials, orientation, roof shape, walls, and overhangs, with factors that determine thermal comfort, while exploring passive design principles based on local wisdom as a reference for sustainable and climate-responsive building design.

Tabel 3. Relationship between physical elements and physical factors

No	Physical Elements	Physical Data of the Memarong Nok Building	Physical Data of the Memarong Mak Building	Relationship between physical elements and physical factors
1	Ventilation	WWR = 31.4%	WWR = 26.5%	Natural ventilation in traditional buildings plays a significant role in controlling indoor air temperature and relative humidity. Relatively large and widely spaced openings allow for effective cross ventilation. This condition is reflected in the THI value, which remains in the fairly

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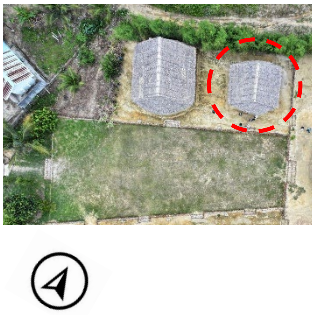
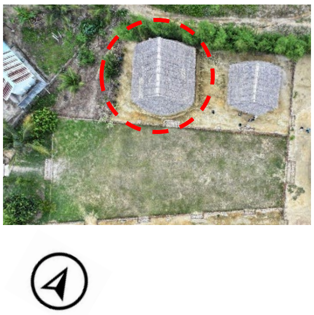
No	Physical Elements	Physical Data of the Memarong Nok Building	Physical Data of the Memarong Mak Building	Relationship between physical elements and physical factors
				comfortable to comfortable category, as well as the adaptive simulation results, which show that the interior remains in the green zone at an outside temperature of 32°C. However, when the outside temperature rises to 35°C, the effectiveness of natural ventilation begins to decline, so that thermal comfort is no longer fully achieved.
2	Material	Mostly wood, and nipah leaf roofing	Mostly wood, and nipah leaf roofing	This material has low thermal conductivity and low heat capacity, which helps reduce heat inside buildings. It allows for faster heat release at night and reduces air temperature increases in rooms during the day. The performance of this material supports THI results that indicate a comfortable to moderately comfortable category.
3	Orientation	Southeast 	Southeast 	The orientation of the Memarong Nok and Memarong Mak traditional building, which faces southeast, helps reduce direct exposure to afternoon sunlight, which generally has higher heat intensity. This orientation helps reduce the increase in the surface temperature of the building envelope and indirectly keeps the air temperature inside the room more stable. In addition, this orientation supports the utilization of the prevailing wind direction, thereby

No	Physical Elements	Physical Data of the Memarong Nok Building	Physical Data of the Memarong Mak Building	Relationship between physical elements and physical factors
				increasing the effectiveness of natural ventilation and airflow velocity within the building.
4	Roof Shape			The steeply sloped gable roof effectively reduces direct solar radiation and accelerates the removal of hot air through the upper space of the building. The large volume of the roof space creates a thermal buffer that inhibits heat transfer to the activity space below. In addition, the nipah leaf roofing material helps lower the roof surface temperature compared to modern materials with high heat absorption, although its effectiveness decreases when the outside temperature rises to 35°C.
5	Wall			Building walls that use wood materials with limited openings play a role in reducing heat storage and maintaining relative humidity in the room. However, the limited porosity and lack of ventilation gaps in the walls prevent optimal micro air exchange. As a result, in high ambient temperatures, the air temperature in the room increases more easily and thermal comfort tends to decrease, as reflected in the THI value, which is in the moderately comfortable category.

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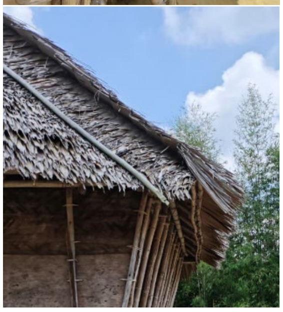
No	Physical Elements	Physical Data of the Memarong Nok Building	Physical Data of the Memarong Mak Building	Relationship between physical elements and physical factors
6	Overhang	 	 	The overhangs on Memarong Nok and Memarong Mak traditional buildings serve as effective passive design elements in reducing direct solar radiation on the walls and openings of the buildings. The elongated dimensions of the overhang and the use of lightweight roofing materials can lower the surface temperature of the building envelope, thereby helping to maintain a lower indoor air temperature and reducing the radiant heat load. Protection of the openings also allows for optimal natural ventilation without excessive heat exposure, thereby supporting humidity control and air movement within the space. In both buildings, the overhang proved to support adaptive thermal comfort up to an outside temperature of 32°C, but its effectiveness began to decline when the ambient temperature rose to 35°C due to the dominance of convective heat from the outside air, which caused a decrease in the level of thermal comfort inside the space, especially at Memarong Mak.

Source: Analysis (2025)

C. Recommendations for Passive Design Strategies in Memarong Nok and Memarong Mak Traditional Buildings

Based on the results of thermal comfort analysis and the relationship between physical elements of the building and physical factors that determine comfort, the Memarong Nok and Memarong Mak Traditional Buildings demonstrate the application of passive design strategies that are adaptive to the humid tropical climate. Natural ventilation strategies are a key aspect that needs to be maintained and optimized, particularly through the arrangement of openings that allow for effective cross ventilation. The ratio of openings to walls should be adjusted to increase airflow velocity in the space without causing excessive heat due to direct radiation.

The use of natural materials with low thermal conductivity, such as wood and roof coverings made from nipah leaves, is recommended because they have been proven to reduce heat accumulation and maintain stable humidity levels indoors. This strategy needs to be supported by building orientation that is responsive to the direction of the sun and prevailing winds, so that exposure to heat radiation can be minimized while maximizing the potential for natural ventilation. Roof shapes with steep slopes and adequate roof space volume are recommended as important elements in heat control, as they function as thermal buffers and assist in the natural removal of hot air. In addition, the use of long, proportional overhangs on building openings should be considered to protect walls and windows from direct solar radiation and rain, without obstructing air flow. The combination of these passive design strategies shows that the principles of local wisdom in traditional buildings can be adapted as an approach to designing contemporary buildings that are sustainable and oriented towards the thermal comfort of users.

RESULTS AND DISCUSSION

This study shows that the Memarong Nok and Memarong Mak Traditional Buildings are generally capable of providing indoor thermal comfort conditions that fall into the comfortable to moderately comfortable category. The results of adaptive thermal comfort simulations based on ASHRAE Standard 55 and Thermal Humidity Index (THI) calculations indicate that both buildings have good adaptive capabilities to humid tropical climatic conditions, although comfort performance tends to decline when the ambient temperature rises to extreme conditions. The findings of this study confirm that passive design strategies applied to traditional buildings, such as natural ventilation, the use of natural materials, proper building orientation, roof shape, and the presence of overhangs, play a significant role in controlling air temperature, humidity, wind speed, and radiation exposure within the space. The difference in comfort levels between Memarong Nok and Memarong Mak shows that variations in the configuration of physical building elements affect the effectiveness of thermal control.

Based on these results, this study confirms that passive design principles based on local wisdom have a potential to be used as a reference in the design of contemporary buildings that are sustainable and climate-responsive such as the use of lightweight natural materials, extended roof overhangs, and cross-ventilation configurations. Further research is recommended to examine the development of these passive design strategies through advanced quantitative approaches or design optimization simulations, as well as to test their application in the context of modern buildings with different characteristics and functions.

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