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Thermal Performance Evaluation and Its Effect on Visitor Comfort and Exhibits in Museum Bahari Jakarta

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ABSTRACT

This study evaluates the thermal performance in Museum Bahari, Jakarta, and its impact on visitor comfort and exhibit preservation. The research emphasizes the challenges of maintaining thermal comfort and environmental stability in a tropical climate while preserving the historical integrity of the building. Using a mixed-method approach, temperature and humidity levels were measured in both naturally ventilated and air-conditioned spaces, complemented by visitor feedback surveys. The results highlight the inadequacy of natural ventilation, with average temperatures exceeding comfort thresholds (29.7°C), and the limited effectiveness of air-conditioned spaces. Recommendations include adopting passive cooling strategies, optimizing ventilation openings, and integrating modern climate control systems compatible with historical architecture. These findings contribute to sustainable heritage conservation and visitor satisfaction.

Keywords: Adaptive reuse, thermal comfort, visitor satisfaction, museum exhibitions

1. Introduction

Historic buildings, like Museum Bahari in Jakarta, serve as vital connections to cultural heritage, offering insights into Indonesia's maritime history while providing functional spaces for modern use. Built during the colonial era, Museum Bahari exemplifies adaptive reuse, transforming its original purpose into a space that bridges historical preservation with contemporary functionality.

These structures face significant challenges in meeting contemporary environmental standards, particularly in tropical climates characterized by high humidity and temperature fluctuations. Thermal comfort, defined as the condition of mind expressing satisfaction with the thermal environment, is essential not only for visitor satisfaction but also for the preservation of delicate artifacts such as wooden or textile exhibits.

Achieving thermal comfort in historical buildings is complicated by their architectural constraints. Museum Bahari's design, including thick walls, large windows, and high ceilings, was optimized for natural ventilation but falls short under modern comfort expectations. These features, while preserving historical aesthetics, pose challenges in regulating indoor temperatures and humidity levels without compromising the building's structural integrity.

Previous studies have underscored the importance of stable microclimates in museums. Fluctuating temperature and humidity levels can accelerate the deterioration of sensitive artifacts and negatively affect visitor experiences. International standards, such as those set by ASHRAE, recommend maintaining temperatures of 22 ± 1°C and relative humidity of 50 ± 5% for optimal conditions.

This study investigates the thermal performance of Museum Bahari's naturally ventilated and air-conditioned spaces. By assessing compliance with comfort standards and gathering visitor feedback, the research aims to identify practical strategies for improving environmental conditions. Furthermore, by linking findings to broader

sustainability goals, such as energy efficiency and heritage conservation, the study contributes actionable insights to the field of adaptive reuse and sustainable building management.

Research Objectives:
1. Assess thermal conditions in naturally ventilated exhibition spaces.
2. Evaluate thermal performance in air-conditioned rooms.
3. Analyze visitor perceptions of thermal comfort.

2. Material and Methods

2.1. Study Object

The study was conducted at Museum Bahari, located in Penjaringan, North Jakarta, Indonesia, housed in a historic building from the colonial era, originally constructed during the Dutch East India Company (VOC). As an example of adaptive reuse, the building was converted into a museum displaying maritime artifacts, ship models, and historical exhibits related to Indonesia's naval heritage.

The architecture of the museum includes large windows, high ceilings, and thick walls, designed for natural ventilation. However, these elements pose challenges in meeting modern standards for thermal comfort and environmental control. The museum is divided into various exhibition halls, each with different sizes, layouts, and ventilation systems. Some rooms rely solely on natural ventilation through open windows, while others are equipped with air conditioning (AC) to enhance thermal comfort and protect sensitive artifacts from temperature and humidity fluctuations.

The study focuses on comparing the thermal performance of naturally ventilated rooms (Rooms 1, 2, and 3) with air-conditioned rooms (Rooms 4, 5, 6, and 8). The goal is to assess the effectiveness of these two ventilation systems in maintaining thermal comfort for both visitors and museum collections.

Museum Bahari plays a vital role in preserving Indonesia's maritime heritage and serves as an educational center for local and international visitors. By evaluating and optimizing the environmental conditions in the museum, the study aims to enhance the visitor experience while safeguarding the integrity of its historical structure and collections.

Source: (Suciati, 2022)
Figure 1: The Main Room of Marine Equipment Exhibition

2.2. Study Design

This research employed a mixed-method approach, combining quantitative measurements of indoor thermal conditions with qualitative data from visitor surveys. The objective was to evaluate the thermal performance of different exhibition rooms and analyze visitor perceptions of comfort.

2.3. Data Collection

2.3.1 Thermal Measurements:

a. Temperature, relative humidity, and air velocity were measured using calibrated devices:
1) Thermohygrometer for temperature and relative humidity.
2) Anemometer for air velocity.

b. Measurements were taken at eight predetermined points in each exhibition room, both naturally ventilated and air-conditioned spaces.
c. Data collection occurred between 12:00 PM and 4:00 PM, coinciding with peak outdoor temperatures and visiting hour.

2.3.2 Visitor Surveys:

a. A structured questionnaire was distributed to visitors to capture their perceptions of thermal comfort.
b. Questions assessed their thermal sensation (e.g., hot, neutral, cold) and preferences for changes in temperature.

2.4. Sampling and Room Selection

The museum's exhibition spaces were categorized based on ventilation systems:
a. Naturally Ventilated Rooms: Exhibition spaces with open windows and no air conditioning.
b. Air-Conditioned Rooms: Spaces equipped with air conditioning for temperature control.

The selected rooms included:
a. Naturally Ventilated: Rooms 1, 2, and 3.
b. Air-Conditioned: Rooms 4, 5, 6, and 8.

2.5. Data Analysis

a. Quantitative Analysis:
1) Collected data on temperature, humidity, and air velocity were statistically analyzed to determine the thermal performance of each room.
2) Graphs and tables were generated to visualize trends and compare conditions between naturally ventilated and air-conditioned spaces.

b. Qualitative Analysis:
1) Visitor feedback from the surveys was analyzed to assess satisfaction with the thermal environment.
2) Regression analysis was conducted to identify the relationship between measured conditions and perceived comfort levels

2.6. Standards and Benchmarks

The study referred to international standards for thermal comfort and artifact preservation:

1) **ASHRAE Standards [7]**: Recommends indoor temperatures of 22 ± 1°C and relative humidity of 50 ± 5% for museum spaces.
2) **Visitor Comfort**: Focused on achieving thermal neutrality as the optimal state for satisfaction.

Table 1: Definitions of Several Terms Related to Thermal Comfort for Different Thermal Concepts

	ASHRAE scale (Thermal Sensation)	Bedford scale (Thermal Comfort)	Acceptability (Thermal Satisfaction)	Preference (McIntyre)
3	hot	much too warm	unacceptable	want cooler
2	warm	Too warm		
1	slightly warm	comfortably warm		
0	neutral	comfortable	acceptable	No change
-1	slightly cool	comfortable cool		
-2	cool	Too cool	unacceptable	Want warmer
-3	cold	Much too cool		

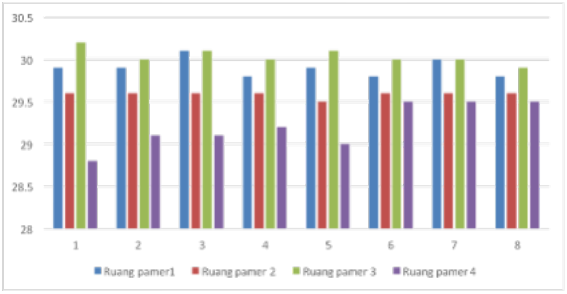
Source: (ASHRAE RP-884, 1998)

3. Results and Discussions

This section presents the findings of the study, focusing on the thermal performance of Museum Bahari's exhibition spaces. It includes an analysis of measured environmental conditions and visitor perceptions, providing insights into the effectiveness of natural ventilation and air conditioning systems.

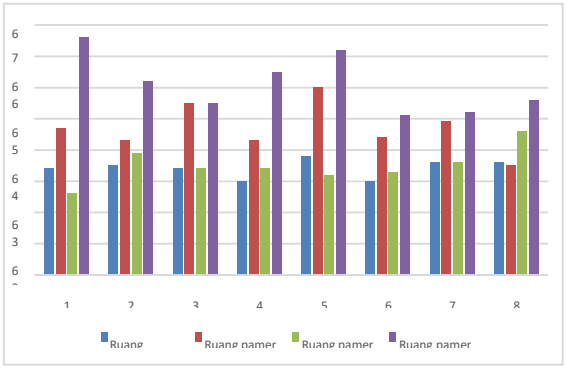
3.1. Thermal Conditions in Naturally Ventilated Rooms

Measurements in the naturally ventilated exhibition spaces revealed the following:
a. Temperature:
The average temperature ranged between 29.0°C and 30.2°C, with a mean value of 29.7°C across the monitored points. These values exceeded the recommended comfort range of 22–26°C.



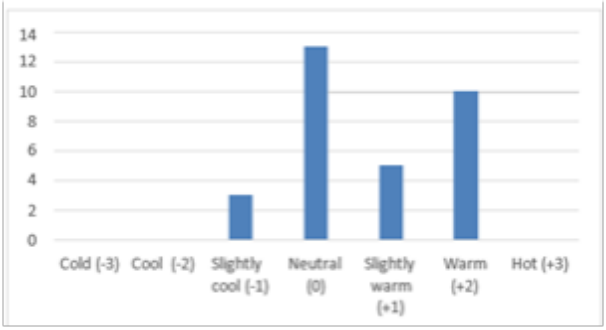
Source: (Authors, 2024)
Figure 2: Graph of Indoor Air Temperature in an Exhibition Room without using Air Conditioning (AC)

b. Relative Humidity (RH):
Humidity levels in these rooms ranged between 61.6% and 66.6%, with an average of 63.4%. Although slightly above the recommended 50–60%, the values remained within acceptable limits for artifact preservation but less ideal for visitor comfort.



Source: (Authors, 2024)
Figure 3: Graph of Relative Air Humidity in the Exhibition Room Without Using Air Conditioning (AC)

c. Air Velocity:
Observations noted minimal air movement, leading to stagnant conditions in some areas. Rooms with higher window openings exhibited slightly better air circulation but still failed to achieve sufficient cooling.



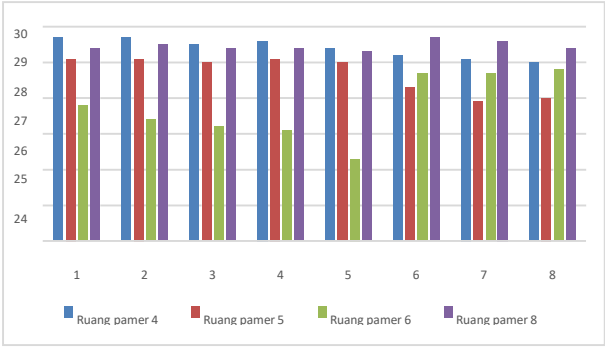
Source: (Authors, 2024)
Figure 4: Graph of Data Tabulation of Visitor Sensations Regarding Air Temperature in the Exhibition Room Without Using Air Conditioning (AC)

Visitor Perceptions:
The survey results indicate that most visitors felt comfortable. This is reflected in the graph above, which shows that the thermal condition of the exhibition room is still neutral/comfortable.

3.2. Thermal Conditions in Air-Conditioned Rooms

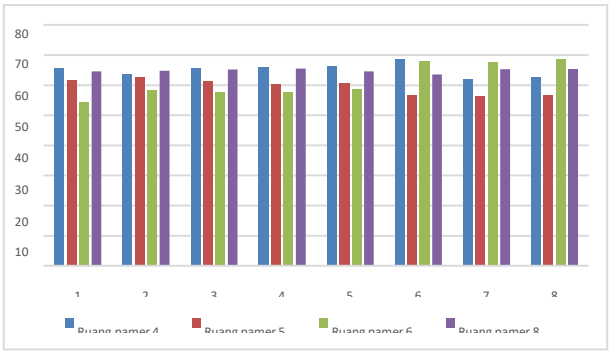
In exhibition spaces equipped with air conditioning, the following conditions were observed:

a. Temperature:
The average temperature was 28.8°C, ranging from 26.3°C to 29.7°C. While these values were closer to the comfort range, they still exceeded the standard for optimal visitor comfort.



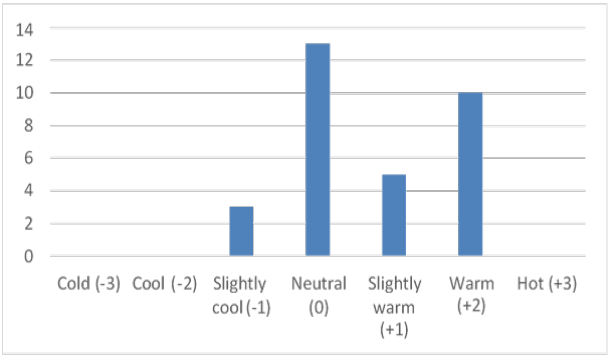
Source: (Authors, 2024)
Figure 5: Graph of Air Temperature in the Exhibition Room Using Air Conditioning (AC)

b. Relative Humidity (RH):
Humidity levels in air-conditioned spaces ranged between 54.3% and 68.4%, with an average of 61.3%. These levels supported artifact preservation but were less ideal for human comfort.



Source: (Authors, 2024)
Figure 6: Graph of Relative Air Humidity in the Exhibition Room Using Air Conditioning (AC)

c. Air Velocity:
Air-conditioned rooms showed consistent airflow, contributing to a marginal improvement in thermal comfort compared to naturally ventilated rooms.



Source: (Authors, 2024)
Figure 7: Graph of Visitor Sensation Data Tabulation Regarding Air Temperature in the Exhibition Room Without Using Air Conditioning (AC)

Visitor Perceptions:
Most visitors described the thermal environment in air-conditioned rooms as "neutral" or "slightly cool." However, some respondents expressed a preference for even cooler temperatures, suggesting that the cooling systems were not sufficient during peak hours.

4. Conclusion

This study underscores the challenges of maintaining thermal comfort in Museum Bahari while preserving its historical integrity. Naturally ventilated rooms failed to meet comfort standards, and air-conditioned spaces offered only partial relief. Recommendations include:

1. **Passive Cooling**: Implement techniques like shading, cross-ventilation, and improved insulation.
2. **Modern Climate Control**: Integrate systems compatible with heritage architecture.
3. **Future Research**: Explore long-term thermal monitoring, visitor behavior analysis, and sustainable energy solutions.

These measures aim to enhance visitor experiences and contribute to the sustainable conservation of historic structures.

Acknowledgment

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References

[1] Serota N, Tate, Jones M. *National Museum Directors Council: Guiding Principles for Reducing Museums' Carbon Footprint*; 2008.
[2] Balocco C, Grazzini G. Numerical simulation of ancient natural ventilation systems of historical buildings. A case study in Palermo. *J of Cult Her*, 2009;10(2):313-318.
[3] Al Hadrami, S.K. (2014). Head of Museums Maintenance, Sharjah Museums Department. Interviewed by Hawra Askari, Sharjah, UAE, 25 August 2014.
[4] Martinez-Molina A, Boarin P., Tort-Ausina I, Vivancos, JL. Assessing visitors' thermal comfort in historic museum buildings: Results from a post-occupancy evaluation on a case study. *Build and Env*,; 2018;132:291-302.
[5] Ascione F, Bellia L, Capozzoli A, Minichiello F. Energy saving strategies in air-conditioning for museums. *Appl Therm Eng*, 2009;29:676-686.
[6] Ascione F, Minichiello F. Microclimatic control in the museum environment: Air diffusion performance. *Int J of Ref*, 2010;33:806-814.
[7] ASHRAE. *ANSI/ASHRAE Standard 62.1-2007 Ventilation for acceptable indoor air quality*; 2007.
[8] Australian Government. *Adaptive reuse: Preserving our past, building our future*; 2004.