



Thermal Comfort of the Facade at Colonial House of Soekarno's Exile in Brastagi District

Armelia Dafrina^{1*}, Irna Nurul Hidayah¹, Nahrul Qadisah¹, Yetty Sari Bangun¹, Erna Muliana¹, Diana Khairani Sofyan²

¹Study Program of Architecture, Universitas Malikussaleh, Lhokseumawe 24351, Indonesia

²Department of Industrial, Universitas Malikussaleh, Lhokseumawe 24351, Indonesia

*Correspondence: armelia@unimal.ac.id

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ABSTRACT: The Exile House of Soekarno in Berastagi District was a colonial-era architectural asset notable for its distinctive structural features and strong adaptation to the local environment. This study examined the relationship between thermal comfort and the colonial architectural façade of Soekarno's Exile House. A qualitative descriptive-interpretive approach was employed to analyze the visual elements of the façade and their relationship with indoor thermal conditions. Data were collected through photographic documentation, direct observation of building elements, and measurements of indoor air temperature, relative humidity, and air movement. The results showed that the façade of Soekarno's Exile House was closely associated with the building's thermal regulation. The building exhibited a distinctive and monumental visual character. The main characteristics of colonial architecture included the use of durable materials, such as specially blended cement and terrazzo flooring, as well as *Geveltoppen*, acroteria roof elements, a geometrically symmetrical façade, wooden-framed windows, and dormer elements. Classical European decorative features, including pillars and capitals, were combined with local decorative variations found in elements such as the crepidoma and tympanum. Regarding thermal comfort, the building orientation, large louvered (*krepyak*) windows, high ceilings, and thick walls functioned as passive thermal-control elements that promoted natural air circulation and helped stabilize indoor temperatures in response to Berastagi's cool mountainous climate. Measurements of air temperature, relative humidity, and air movement were used to evaluate the contribution of these architectural elements to indoor thermal conditions. The findings indicated which building elements played important roles in maintaining indoor comfort and demonstrated how their architectural characteristics contributed to thermal performance. The study concluded that the colonial architecture of Soekarno's Exile House incorporated façade and building elements that were closely integrated with thermal performance, demonstrating how historical architectural design responded to local climatic conditions while maintaining its distinctive colonial character.

KEYWORDS: Building façade; thermal comfort; air temperature; air movement; characteristic colonial architecture; Soekarno exile house Brastagi

1. Introduction

Before Indonesia gained independence, Dutch architects developed a colonial architectural style that combined Western design principles with adaptations to local climatic and cultural conditions. This architectural approach spread across the Indonesian archipelago, including North Sumatra. During the colonial period, the Dutch constructed residences, government offices, commercial buildings, and defensive structures that displayed distinctive colonial architectural characteristics [1]. Over time, these buildings became important physical evidence of the architectural and historical development of Indonesian cities under colonial rule.

Berastagi, located in Karo Regency, North Sumatra Province, had a long history associated with the Dutch colonial period. Its cool mountainous climate and strategic location encouraged the development of various facilities during that period. The colonial government constructed government facilities, economic centers, and residential buildings for Dutch officials and residents in North Sumatra [2]. These residential buildings differed considerably from traditional local houses in their architectural form, spatial organization, materials, and façade composition and consequently became recognized as part of the region's Dutch colonial architectural heritage [3]. The surviving buildings not only contributed to the architectural character of the area but also served as physical records of its historical and urban development [4].

One of the remaining colonial-era buildings in Berastagi was the Soekarno Exile House, which served as a place of exile for Indonesia's first president [5]. The building retained several characteristics associated with colonial architecture, including a symmetrical façade, brick-and-plaster construction, a hipped roof, and relatively large openings [6]. These architectural elements contributed not only to the building's visual identity but also to its environmental performance. The façade configuration, material selection, roof geometry, building orientation, and size and placement of openings facilitated natural ventilation and responded to Berastagi's cool mountainous climate [7]. Such passive design strategies were important because thermal comfort influenced occupants' ability to perform activities comfortably and affected the overall environmental quality of indoor spaces [8, 9].

Although Berastagi continued to experience physical and urban development, colonial buildings such as the Soekarno Exile House remained important architectural records of colonial history and the transformation of the built environment [10]. However, changes in building function, physical modifications, deterioration, and contemporary requirements had affected the authenticity and original characteristics of some colonial structures [11]. Conservation efforts therefore required an understanding not only of their historical and visual characteristics but also of how their architectural elements responded to local environmental conditions.

Therefore, this study aimed to identify and analyze the colonial façade characteristics of the Soekarno Exile House and to assess the contribution of its architectural elements to indoor thermal comfort. Particular attention was given to façade composition, building materials, roof configuration, openings, and other passive design features that potentially influenced air temperature, relative humidity, and air movement. By integrating architectural and thermal assessments, the study sought to provide a more comprehensive understanding of the relationship between heritage architecture and environmental performance and to

contribute to the documentation and conservation of colonial architectural heritage in North Sumatra [12].

2. Materials and Methods

2.1 *Characteristics of Colonial Architecture.*

Colonial architecture has distinctive characteristics that differentiate it from other architectural styles and building types [13]. These characteristics reflect the influence of European architectural principles while also demonstrating adaptations to local climatic conditions, available materials, and construction techniques. In this study, the colonial architectural characteristics of the Soekarno Exile House were identified through systematic observation of its physical form, façade composition, decorative features, and structural elements. The assessment considered several characteristic elements commonly associated with colonial architecture, including gables or gevels, towers, dormers, tympanums, balustrades, bovenlicht or ventilation openings, weather vanes, acroteria along the roof ridge (nok acroterie), and geveltoppen or decorative gable ornaments. Other features included decorative metalwork, ornamental façades, thick walls, expansive front verandas, classical Greek-style columns, colonnades, and white-painted exterior surfaces. The architectural composition was also examined in terms of façade symmetry, wooden window frames, tall building proportions, crepidoma or raised bases, false chimneys, and double-door entrances or porches. Collectively, these elements were used as architectural indicators to determine the extent to which the Soekarno Exile House retained its original colonial character. Their presence, physical condition, arrangement, and visual relationship were subsequently examined to understand how European colonial design principles were adapted to the architectural and environmental context of Berastagi. These elements were used as architectural indicators to determine the extent to which the building retained its colonial characteristics. Each feature was identified through direct observation and photographic documentation and was subsequently compared with the characteristics of colonial architecture described in the literature [13]. Particular attention was given to the façade because it represented the most visible expression of the building's architectural identity and included important elements such as openings, ornaments, structural proportions, and roof features.

2.2 *Thermal Comfort Parameters.*

Thermal comfort is an important aspect of building performance because it influences occupants' comfort and their ability to perform activities effectively in residential, educational, and workplace environments [14]. Thermal conditions within a building are influenced by several environmental and architectural factors, including air temperature, relative humidity, air movement, building orientation, openings, roof configuration, solar exposure, and surrounding vegetation. According to Georg Lippsmeier in *Tropenbau/Building in the Tropics*, the comfortable air-temperature range for equatorial and warm-humid regions is approximately 22.5–29°C, accompanied by a relative humidity range of 20–50% [15]. Lippsmeier also identified several architectural and environmental factors associated with thermal comfort in tropical buildings, including building orientation, cross-ventilation, roof slope, solar protection, air humidity, and vegetation [16]. These parameters

provided the theoretical basis for examining how the architectural characteristics of the Soekarno Exile House responded to the local climatic conditions of Berastagi. In this study, thermal comfort was evaluated by relating measured indoor environmental conditions to the physical characteristics of the building. Air temperature, relative humidity, and air movement were considered the principal environmental parameters, while building orientation, window and door openings, wall characteristics, roof configuration, and other façade elements were examined as architectural factors that potentially influenced indoor thermal conditions.

2.3. Research Design.

This study employed a qualitative descriptive–interpretive approach to identify the colonial architectural characteristics of the Soekarno Exile House in Berastagi and to examine their relationship with thermal comfort. The descriptive approach was used to document the existing physical characteristics of the building, while the interpretive approach was applied to explain the architectural significance and environmental functions of the observed elements. The research focused on the building façade and other architectural components that could influence both its colonial identity and indoor environmental performance. These included windows, doors, ventilation openings, roof eaves, roof forms, ornaments, walls, construction materials, and façade composition. The research design therefore integrated architectural documentation with an assessment of thermal conditions to provide a more comprehensive understanding of the relationship between heritage characteristics and environmental performance.

2.4. Data Collection.

Primary data were collected through direct field observation, interviews with relevant stakeholders, photographic documentation, architectural sketches, and measurements of indoor environmental conditions. Direct observation was conducted to identify the physical condition, form, dimensions, materials, ornaments, and spatial arrangement of the architectural elements. Photographs and sketches were used to systematically document the façade and other significant building components. Interviews were conducted to obtain supplementary information regarding the building's historical background, physical changes, maintenance, and conservation. The information obtained from interviews was used to support the interpretation of the field observations rather than as the sole basis for identifying architectural characteristics. Thermal measurements were conducted to assess the indoor environmental conditions of the building. The parameters included air temperature, relative humidity, and air movement. These measurements were subsequently interpreted in relation to architectural features such as building orientation, window configuration, ventilation openings, wall thickness, roof geometry, and shading elements. This approach allowed the study to examine whether the observed architectural features potentially contributed to passive thermal regulation.

2.5. Data Analysis.

The collected data were analyzed in two stages. First, the architectural characteristics of the Soekarno Exile House were classified according to the colonial architectural indicators described in Section 2.1. Each observed feature was documented and compared with the

characteristics reported in the literature [13]. This analysis was used to identify which colonial architectural elements remained present and to assess their physical condition and level of authenticity. Second, the thermal measurements were evaluated in relation to the thermal comfort criteria and architectural factors described in Section 2.2 [15, 16]. Air temperature, relative humidity, and air movement were interpreted together with building orientation, openings, wall characteristics, roof configuration, solar protection, and vegetation. Rather than evaluating these parameters independently, the analysis examined how their interaction potentially influenced indoor thermal conditions. Finally, the architectural and thermal findings were integrated to determine whether the colonial façade and other building elements served both visual and environmental functions. This descriptive–interpretive methodology was consistent with the study's objective of understanding the architectural and environmental characteristics of a historic façade while providing information that could support future documentation and conservation strategies for Dutch colonial architectural heritage in North Sumatra [5].

3. Results and Discussion

3.1. Building Profile and Historical Context.

The Soekarno Exile House is a historically significant building associated with an important period in Indonesia's struggle for independence. The building is located in Lau Gumba Village, Berastagi District, Karo Regency, North Sumatra. Berastagi is a mountainous area characterized by a relatively cool climate and has long developed as a destination for recreation and tourism. During the colonial period, the area was also valued for its mountain environment and climatic conditions, which influenced the development and architectural characteristics of buildings constructed in the region. The present study examined the architectural characteristics of the Soekarno Exile House, with particular emphasis on its façade and the contribution of its architectural elements to indoor thermal conditions. The analysis focused on identifying colonial architectural features that remained visible in the building and examining how elements such as building orientation, openings, roof configuration, shading, materials, and vegetation interacted with the local climate. In addition to documenting its architectural significance, the findings provide information that may support future conservation strategies by identifying features that contribute simultaneously to the historical identity and environmental performance of the building.

3.2. Architectural Features Affecting Thermal Comfort.

The thermal performance of the Soekarno Exile House was initially assessed through direct observation of architectural and environmental features associated with passive thermal control. Figures 1–5 document the principal features considered in the analysis, including building orientation, cross-ventilation, solar protection, vegetation, and roof slope. Figure 1 illustrates the relationship between building orientation and cross-ventilation. The orientation of the building influenced the exposure of the façade to solar radiation and prevailing airflow, while openings on different sides of the building provided pathways for natural ventilation. The arrangement of these openings potentially facilitated the movement of outdoor air through the interior spaces, thereby reducing heat accumulation.

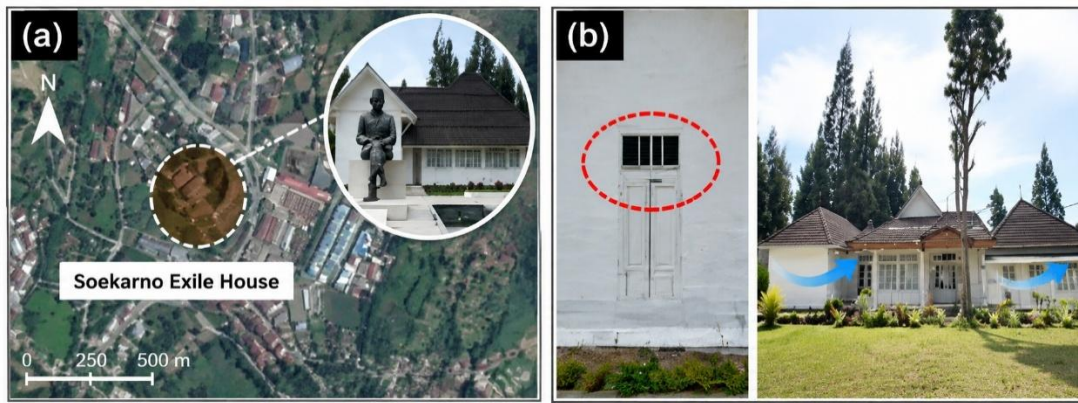


Figure 1. Building orientation (a) and cross-ventilation configuration (b).

Figure 2 shows the solar-protection features and surrounding vegetation. Shading provided by architectural elements reduced direct solar exposure to walls and openings, while vegetation around the building provided additional environmental protection. Together, these features potentially moderated solar heat gain and contributed to a more stable microclimate around the building.

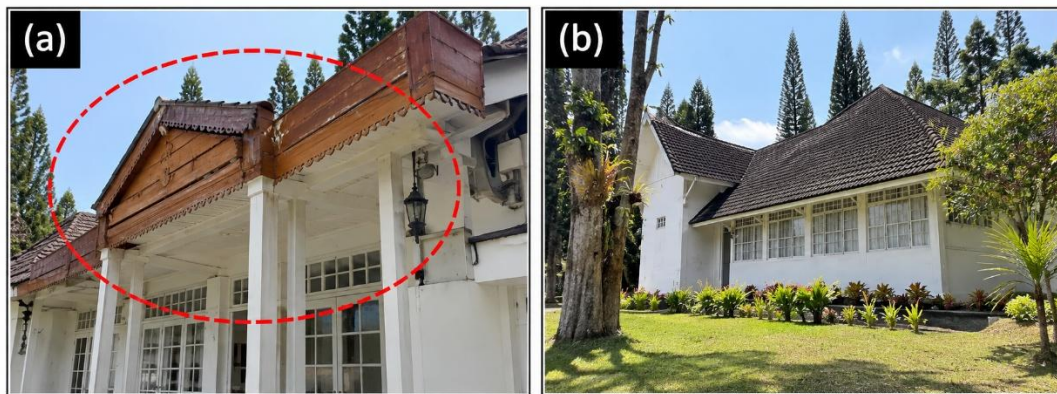


Figure 2. Solar Protection Provided by the Roof Overhang and Veranda (A); Vegetation Surrounding the Building and Contributing to the Outdoor Microclimate (B).

Figure 3 further illustrates the relationship between the arrangement of openings and vegetation surrounding the building. Openings located on different sides allowed air to move through the occupied spaces, while vegetation provided shading and potentially reduced the temperature of the air surrounding the building before it entered through the openings.



Figure 3. Cross-ventilation through the arrangement of façade openings (a); side vegetation surrounding the building and providing natural shading (b).

Figure 4 presents additional views of the building orientation and ventilation arrangement. The relatively open position of the building, without major adjacent structures directly obstructing its façades, supported natural airflow around the building. This condition was important for maintaining cross-ventilation through windows, doors, and other openings.



Figure 4. Building orientation in relation to the surrounding environment (a) and cross-ventilation through façade openings (b).

The roof configuration is shown in Figure 5. The sloping roof represents an important architectural feature because roof geometry affects solar exposure, rainwater drainage, and the thermal conditions of the spaces beneath the roof. In combination with the building's relatively high interior volume, the roof configuration potentially helped separate occupied spaces from heat accumulated in the upper part of the building.

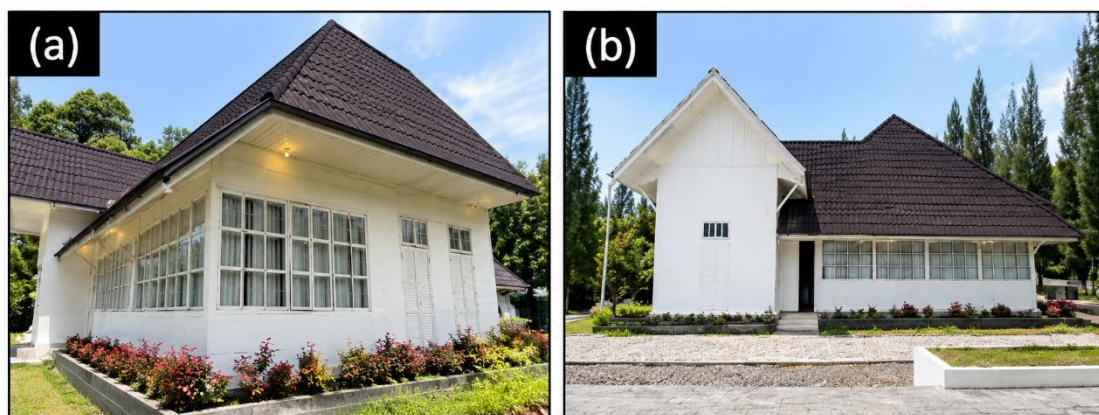


Figure 5. Roof slope viewed from the front (a) and side (b).

3.3. Relationship Between Colonial Architecture and Thermal Comfort.

The architectural and thermal variables examined in this study are summarized in Table 1. The assessment combined colonial architectural characteristics derived from Handinoto's theoretical framework with thermal-comfort parameters based on Georg Lippsmeier's approach. This combination allowed the façade to be evaluated not only as a historical and visual composition but also as an environmental interface between outdoor climatic conditions and indoor spaces. The two groups of variables were closely related. Colonial elements such as ventilation openings, verandas, windows, wall construction, and façade composition contributed to the architectural identity of the building while potentially performing environmental functions. Meanwhile, building orientation, cross-ventilation, roof slope, solar protection, humidity, and vegetation were examined to determine how the

building responded to the local climatic environment. The integration of these two perspectives was particularly relevant because conserving a heritage building should consider not only its visual appearance but also the environmental functions embedded in its original architectural design.

Table 1. Variables and parameters used to evaluate colonial architectural characteristics and thermal comfort.

Theoretical Basis	Variable	Parameters	Area of Assessment
Handinoto theory	Colonial architectural characteristics	Bovenlicht, crepidoma, white-painted exterior, symmetrical façade, ornamental façade	Façade
Georg Lippsmeier theory	Thermal comfort	Building orientation, cross-ventilation, roof slope, solar protection, air humidity, vegetation	Building and façade

3.4. Air and Wall Surface Temperature.

Measurements of indoor and outdoor air and wall surface temperatures were used to evaluate the thermal response of the building. The results indicated differences between indoor and outdoor thermal conditions, suggesting that the building envelope and passive architectural features moderated heat transfer from the exterior to the interior.

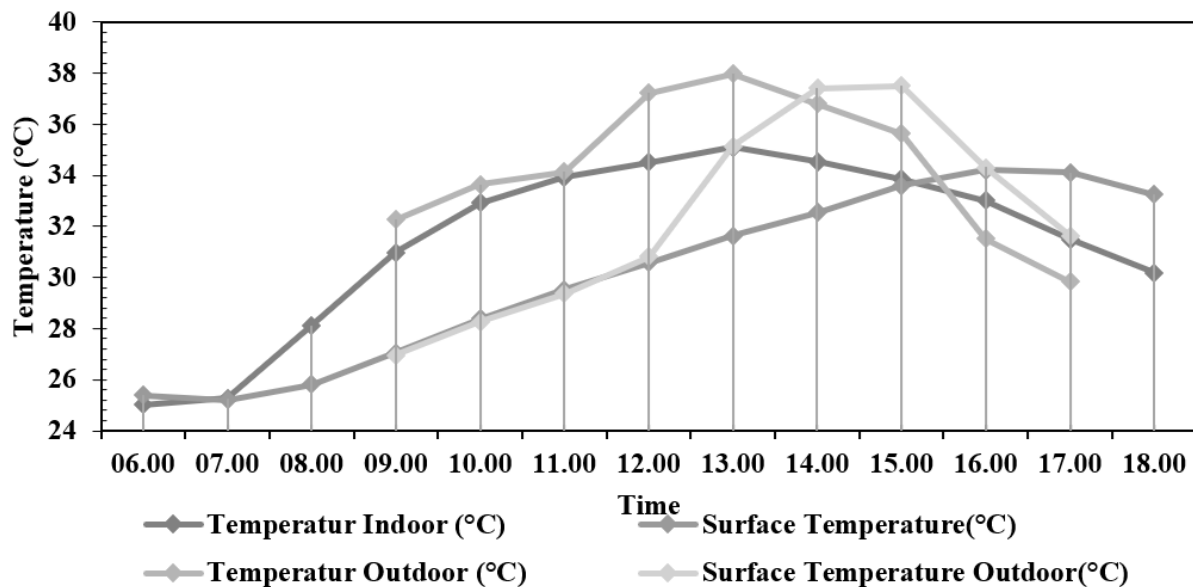


Figure 6. Variations in Indoor and Outdoor Air and Wall Surface Temperatures During the Observation Period.

Figure 6 shows the variation in measured temperatures during the observation period. The highest recorded indoor temperature occurred at 13:00, reaching approximately 35°C, when the corresponding outdoor temperature reached approximately 38°C. At 17:00, the indoor temperature was approximately 34°C compared with approximately 36°C outdoors. Thus, despite changes in outdoor temperature throughout the day, the measured indoor conditions remained lower than the corresponding outdoor conditions.

The difference cannot be attributed to cross-ventilation alone. Rather, it likely reflected the combined influence of building orientation, shading, wall characteristics, roof configuration, openings, and natural ventilation. In particular, cross-ventilation promoted air exchange, while shaded openings and other solar-protection features reduced direct solar radiation entering the interior. These results suggest that the colonial architectural

configuration provided a degree of passive thermal moderation under the climatic conditions recorded during the study.

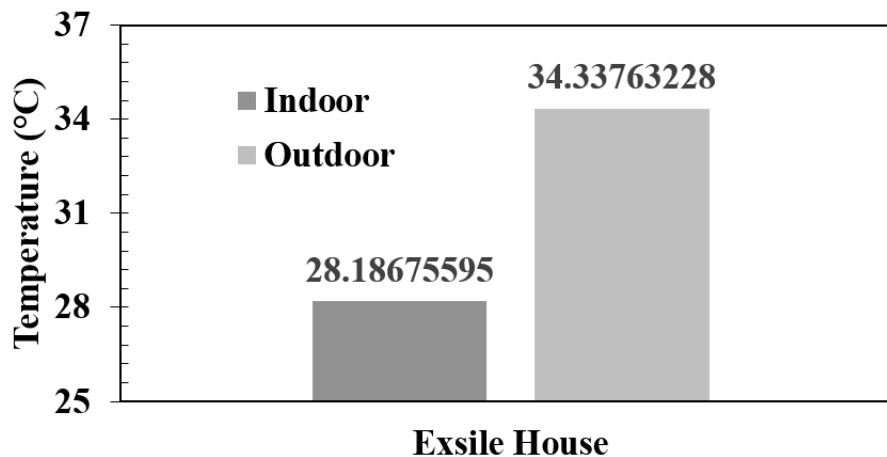


Figure 7. Differences Between Indoor and Outdoor Air Temperatures During the Measurement Period.

Figure 7 more clearly demonstrates the differences between indoor and outdoor air temperatures. Variations were observed during the measurement period, although measurements at different observation points were not always conducted simultaneously. Therefore, direct comparisons between individual measurement points should be interpreted cautiously. Nevertheless, the general pattern indicated that indoor temperatures tended to remain below the corresponding outdoor conditions during periods of high external temperature. This pattern was associated with the combined effects of building orientation, cross-ventilation, roof configuration, and solar protection. These architectural features reduced direct heat gain and promoted natural air exchange, thereby contributing to indoor thermal regulation.

3.5. Relative Humidity.

Relative humidity was another important parameter used to evaluate the indoor thermal environment. In a naturally ventilated building, indoor humidity is strongly influenced by outdoor atmospheric conditions because large openings permit continuous exchange between indoor and outdoor air.

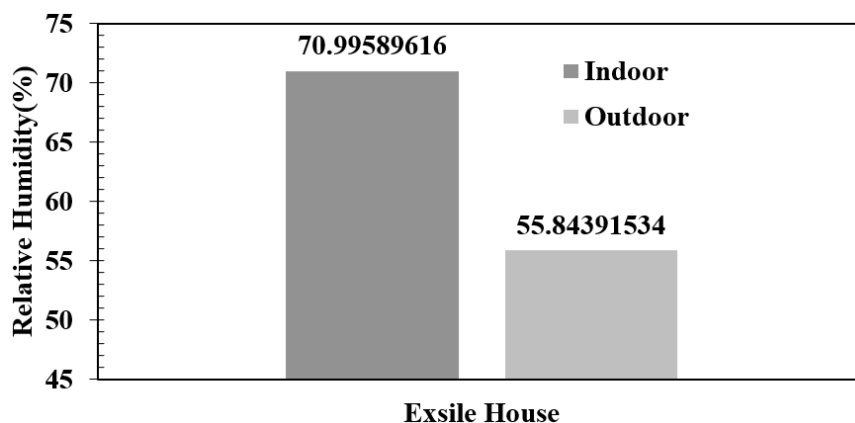


Figure 8. Differences in Relative Humidity Between the Indoor and Outdoor Observation Points.

Figure 8 shows the differences between indoor and outdoor relative humidity recorded during the observations. The results indicated that the building had a limited ability to independently regulate indoor humidity. The presence of numerous louvered windows promoted continuous natural ventilation, which was beneficial for air movement but also allowed humid outdoor air to enter the building. Consequently, the indoor relative humidity remained strongly influenced by external conditions. This finding demonstrates an important trade-off in passive building performance: large ventilation openings can improve airflow and reduce accumulated heat, but they do not necessarily reduce humidity when the outdoor environment itself is humid.

3.6. Air Movement and Natural Ventilation.

Air movement was evaluated to determine how effectively the building configuration supported natural ventilation. The relatively open surroundings of the Soekarno Exile House provided an important advantage because airflow around the façades was not substantially obstructed by immediately adjacent structures.

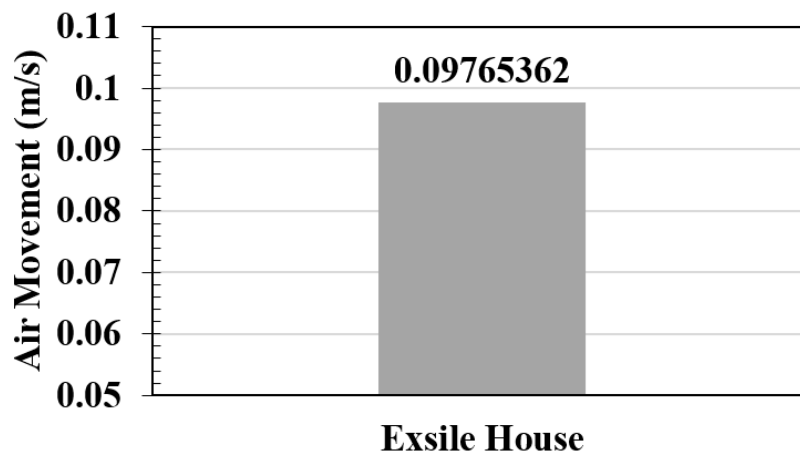


Figure 9. Air Movement and Natural Ventilation Within the Observed Building.

As illustrated in Figure 9, the building configuration supported airflow through openings located on different sides of the structure. This arrangement facilitated horizontal cross-ventilation, while the relatively high internal volume and roof configuration potentially supported vertical air movement. The combined airflow pattern promoted the replacement of warmer indoor air with outdoor air and reduced the accumulation of stagnant air within occupied spaces. The effectiveness of this system was also influenced by the size, position, and type of windows and ventilation openings.

Overall, the measurements of air temperature, relative humidity, and air movement indicated that the thermal conditions of the building were influenced by the interaction of several passive architectural features rather than by a single element. Building orientation, openings, cross-ventilation, roof geometry, solar protection, and surrounding vegetation operated collectively as part of the building's environmental response. However, because the study was observational and measurements were not conducted simultaneously at all locations, these relationships should be interpreted as associations rather than direct evidence of the individual thermal contribution of each architectural element.

3.7. Colonial Facade Characteristics and Their Environmental Functions.

The Soekarno Exile House retained several architectural features associated with colonial architecture, including bovenlicht openings, ornamental details, a front veranda, colonnades, a white-painted exterior, a symmetrical façade, wooden windows, a raised base or crepidoma, and a double-door entrance [11]. These features contributed to the historical character of the building while several also performed practical environmental functions (Table 2).

Table 2. Colonial architectural characteristics of the Soekarno Exile House and their potential environmental functions.

Architectural Element	Observed Characteristics and Interpretation
Bovenlicht	The bovenlicht consisted primarily of wood and glass and provided additional openings above or around doors and windows. In addition to contributing to the colonial character of the façade, these elements supported daylight penetration and, where operable or ventilated, could contribute to air circulation.
Architectural ornamentation	Decorative elements were observed on door and window frames, fascia boards, and porch columns. Although these elements had a limited direct thermal function, they contributed significantly to the visual identity and colonial architectural character of the building.
Front veranda	The wide front veranda created a semi-outdoor transitional space between the exterior and interior. Its roof provided shade to walls, doors, and windows, reducing direct solar exposure while allowing outdoor air to circulate adjacent to the interior spaces.
Colonnade	The symmetrical colonnade supported the veranda roof and created a rhythmic façade composition. In addition to its visual function, the covered colonnade contributed to shading along the building perimeter.
White-painted exterior	The white exterior represented a characteristic visual feature of colonial architecture. Its relatively light surface could also reduce solar heat absorption compared with darker surfaces, although its actual thermal contribution was not measured separately in this study.
Symmetrical façade	The symmetrical organization of openings and building mass reflected colonial design principles. The regular distribution of openings also facilitated relatively balanced daylight penetration and opportunities for natural ventilation across the façade.
Kupu tarung windows	The wooden double-leaf windows incorporated small louvered openings that permitted daylight and airflow. The louvered configuration provided ventilation while partially limiting direct solar penetration and maintaining privacy.
Crepidoma	The raised building base physically separated the occupied floor from the surrounding ground. This configuration potentially reduced direct moisture transfer from the ground and may have contributed to ventilation beneath or around the floor structure.
Double-door entrance	The two-leaf main entrance emphasized the formal character and symmetry of the façade. When opened, the relatively large entrance also provided an additional pathway for natural ventilation between exterior and interior spaces.

The observations summarized in Table 2 demonstrate that the colonial characteristics of the building were not exclusively decorative. Several elements performed multiple functions by simultaneously contributing to architectural identity, solar protection, daylighting, ventilation, and moisture management. The front veranda, louvered windows, ventilation openings, raised base, and roof configuration were particularly relevant to the building's passive environmental response. However, the thermal functions of individual architectural elements should not be overstated. The present measurements evaluated the building as an integrated system rather than experimentally isolating individual façade components. Therefore, the observed thermal performance resulted from the combined effects of architectural configuration, material characteristics, outdoor climatic conditions, vegetation, and natural ventilation. This integrated relationship between colonial architectural character and passive environmental response represents an important consideration for conservation. Altering original openings, verandas, roof configurations, or ventilation features could affect

not only the historical authenticity of the Soekarno Exile House but also the passive environmental functions embedded within its architectural design.

4. Conclusions

This study demonstrated that the Soekarno Exile House in Berastagi retained distinctive characteristics of Dutch colonial architecture while incorporating passive design strategies adapted to the local mountainous climate. Its principal architectural features included a symmetrical façade, large wooden-framed openings, a broad front veranda supported by colonnades, a white-painted exterior, louvered windows, and timber elements. Although some typical colonial features, such as towers, dormers, and elaborate metal ornamentation, were absent, the remaining elements clearly represented the building's colonial architectural identity and historical significance. The thermal assessment indicated that the building's environmental performance resulted from the combined effects of building orientation, cross-ventilation, roof configuration, shading, façade openings, and surrounding vegetation. Indoor temperatures were generally lower than outdoor temperatures during the observation period, indicating that these passive architectural features contributed to moderating indoor thermal conditions. Wide roof overhangs reduced direct solar exposure, while louvered and double-leaf (*kupu tarung*) openings facilitated natural airflow and provided additional solar protection. Cross-ventilation through openings on different elevations also supported both horizontal and vertical air movement within the building. Overall, the findings showed that the architectural significance of the Soekarno Exile House extended beyond its historical and visual characteristics. Several original colonial elements simultaneously contributed to passive environmental control and indoor thermal comfort. Therefore, future conservation efforts should preserve not only the visual authenticity of the façade but also the functional relationships among openings, verandas, roof overhangs, shading elements, and natural ventilation. Maintaining these features is important for safeguarding both the historical value and climate-responsive design principles embodied in this colonial heritage building in North Sumatra.

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Author Contribution

Authors should clearly specify the roles and contributions of each author involved in the research. This helps to attribute credit appropriately and provides transparency about who was responsible for various aspects of the study. Specific Roles of author as follows: Armelia Dafrina who developed the research idea or hypothesis, designed the research methods and experiments. Yetty Sari Bangun who collected, gathered, or organized the data. Irna Hidayati analyzed or interpreted the data and wrote the manuscript or contributed to drafting and revising, Nahrul Qadisa provided oversight or guidance throughout the research process, Diana Khairani Sofyan who secured the funding or resources for the research.

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