



Identifying Thermal Comfort of Tropical Architectural Concept Building: A Case Study of Expandable House

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ABSTRACT

Tropical architecture is an architectural building concept that focuses on using materials and techniques by the environment and climate in the tropical region. Buildings with tropical architectural styles have special characteristics in adapting to climate conditions, but currently, there are also modern buildings that can be categorized as contemporary tropical buildings. In the context of Batam City, contemporary tropical architectural buildings have not been prominent, especially in residential house applications. Moreover, few residential houses failed to follow thermal comfort in the objective of Batam climate. This study aims to identify thermal comfort elements in residential houses that apply contemporary tropical architectural concepts in the city of Batam. In this case, the author examines "Rumah Tambah" as a case study. By conducting a literature review and comparison of case studies as well as direct observation of the location, this research was conducted using an inductive qualitative method using primary and secondary data. Finally, this research produces an identification of thermal comfort that is applied to residential houses with a contemporary tropical architectural concept and provides recommendations for design elements in residential houses with a contemporary tropical architectural concept in the city of Batam.

ARTICLE INFO

Article History:

Submitted/Received 7 February 2023

First Revised 26 March 2023

Accepted 30 May 2023

First Available online 1 June 2023

Publication Date 1 June 2023

Keyword:

Contemporary Tropical Architecture,
Thermal comfort,
Expandable house,
Batam

1. INTRODUCTION

Tropical architecture is an architectural building concept that focuses on the use of materials and techniques used by the environment and climate in the tropics. Buildings with a tropical architectural style have special characteristics in adapting to climatic conditions, but nowadays there are also modern buildings that can be categorized as tropical buildings. This is achieved through a system that pays attention to air circulation, ventilation, openings, orientation, and the use of modern environmentally friendly materials. Tropical architecture includes everything related to the design of buildings or areas with tropical building characters and their impact on the environment.

Indonesia is a country with rapid economic growth, and as such, many people require housing that suits their lifestyle. However, in some cases, the need for a larger or smaller house may change over time. This is the basis of the expandable house concept, as applied to the expandable house in the city of Batam. An expandable house is an example of a house designed to adapt to the changing needs of its occupants over time. The design is minimalist and makes efficient use of space while considering the surroundings and ecology. This concept is perfect for those who want to have a house that suits their needs over time without having to build a new house (Aminuddin, 2016).

2. THE MATERIALS

2.1. Tropical architecture

Tropical architecture is a design idea that can adapt to the surrounding tropical climate but is still connected to aesthetic values. This concept is important in providing a positive response to the effects of the tropical climate, which takes into account material factors. Batam air circulation and climate are known for its extraordinary heat, limited air movement, and high rainfall. The concept of tropical architecture efforts to prevent negative effects such as humidity. The use of local and natural materials such as wood, bamboo, and natural stone is very important in supporting tropical architectural buildings. Opening or ventilation in this building must pay attention to the direction of morning and evening sun lighting, so as to create a comfortable and healthy temperature in the building, as well as sufficient air circulation for good air (Edyas et.al., 2017)(Widodo, 2021).

Indonesia has two types of regional climates, namely tropical rainforest areas and equatorial rainforest areas. Tropical rainforest areas are found in the wet tropics. The characteristics of this area have a significant influence on the shape of the building. The tropical climate with high air temperature, solar radiation, wind currents, humidity, and rainfall influences the design of the building. The tropical building concept is always related to the adaptation of building forms to climate and includes a casual relationship between climatic conditions and building design (Jhon Alfred Depa Dede et al., 2020). A good architect or designer will balance forms that meet climate adaptation with aesthetic forms for both the exterior and interior of the building. Development and the built environment in areas with a humid tropical climate require a special design because there are specific factors that are only found in that climate. This affects architectural theories, composition, form, function, appearance, and aesthetic value of buildings that are different compared to regions with different climates (Edyas et al., 2017)(Kaharu et.al., 2017)(Mahabell et.al., 2019)

The principles of buildings that apply tropical architecture according to Sugiyatmo (Fitriani & Utami, 2022)(Permana et.al., 2020)(Prianto et.al., 2018)(Saroinsong, 2017):

1) Thermal comfort

The main purpose of implementing tropical architecture is to ensure thermal comfort for users who require a clean environment and not too hot or cold, a quiet environment with a noisy atmosphere, and good lighting to ensure eye health. This is to meet the problems of a tropical climate that must be accepted in user activities (Bambang & Sari, 2021). To achieve the desired thermal performance, several building designs must be specified, namely:

a. Building mass orientation

The orientation of the building affects the user's comfort against rotating sunlight. A north-south-oriented building is a good choice because the sun's rays will heat up all areas of the building facing it. The sun rising from the east can cause uncomfortable heat between 09.00-11.00. Meanwhile, the sun that sets from the west can radiate heat to a maximum between 13.00-15.00. Solar radiation has an effect on buildings and can cause disturbances from the heat and glare of the light. The orientation of the building to the direction of the wind must also be considered to maintain the stability of the air inside the building. Wind direction has a major influence on the orientation of the building (Permana et.al., 2021)(Sujannah, 2019)(TYAS et al., 2015).

b. Green open space

For areas outside the building, the use of materials such as concrete or asphalt should be limited to reduce hot air temperatures so that the rooms inside the building will be more comfortable. Green open space is also very important for the tropics as a solution to reduce temperature and reduce noise levels from the streets as well as a place for water absorption during the rainy season. Planted trees will produce O^2 and absorb CO^2 , SO^2 and heavy metals in air and water. During the day, sunlight will be absorbed for the photosynthesis process (Saroinsong et al., 2017).

c. Selection of materials

The principle in tropical architecture emphasizes the use of materials originating from natural resources around because these materials have durability, heat absorption and have a positive influence on buildings with tropical climates. Timber and mild steel are used for the main building frame and roof, while special aluminum is used in window and door frames to aid in heat and noise transmission. Bricks have fire resistant characteristics and are strong against high pressure, so they are used as wall materials. Bright colors with smooth textures on buildings can reflect sunlight well, while dark colors with rough textures help reduce sunlight (Syahriyah, 2017).

2) Air circulation

In the principles of tropical architecture, air circulation must be improved by various ventilation systems at odds with each other. The shape and position of the mass of the building affect the flow of air into the building. Wind usually flows from areas of high pressure to areas of low pressure. This will affect the position of the building at the location, related to air circulation at that location. Try to make a lot of openings in the building to ensure a continuous flow of air to create a cooling effect (Prianto et al., 2018).

3) Natural lighting during the day

Tropical buildings need lots of openings, such as windows, to let in sunlight. The use of natural sunlight as lighting can save electricity. Apart from windows, light openings such as skylights located on the roof also help to let in sunlight. With windows and skylights, it is at least possible to reduce the need for artificial lighting (Thiodore, 2018).

4) Protection from sunlight and heavy rain

Sunlight causes the temperature inside the building to heat up, to overcome this, secondary skin and overhangs are used. Secondary skin is the outer that is usually used as a building façade, but provides distance so as to create empty space for air circulation. There are various forms of overhangs, but those needed are to control the angle of exposure to the sun and prevent direct rain from entering the room, preventing damage to indoor items (Bambang & Sari, 2021).

2.2 Thermal comfort

Thermal comfort is a person feeling of the surrounding environment. Variables that effect thermal comfort are known as thermal variables, which have different values at each location and are referred to as microclimate variables. Buildings on the mountains and coasts have different levels of thermal comfort (Ardiyanto & Hermawan, 2020).

Thermal comfort can be defined as a temperature balance obtained through heat exchange between the human body temperature and a suitable environment. In this case, thermal comfort is realized through the temperature balance between human and the surrounding environment. This balance achieves a balanced body temperature condition such as metabolic processes, through the processes of evaporation, convection, conduction, and radiation. Metabolic processes in the human body require and emit heat, so the rate of heat exchange between entering and leaving the human body must be balanced (Mahabella et al., 2019).

Reception about thermal comfort is a subjective view of building occupants. Although the role of occupants in influencing thermal comfort is very important, the condition of the building also has the same influence. Therefore, it is important to pay attention to how the characteristics of the building effect the thermal comfort of the occupants (Hermawan et al., 2019).

According to (Meiranny, 2017) thermal comfort is influenced by several factors such as air temperature, wind speed, air humidity, radiation, and subjective factors such as metabolism, clothing, food and drink, body shape, age, and gender. Factors that effect thermal comfort is:

a) Air temperature

Air temperature is an important factor effecting thermal comfort. There are several units used to measure air temperature such as Celsius, Fahrenheit, Reamur, and Kelvin. The ideal humidity and air temperature for human is usually around 37%. Differences in air temperature between regions can be caused by factors such as angle of sunlight, altitude, wind direction, ocean currents, clouds, and duration of irradiation (Mustamin et al., 2017).

b) Radiant temperature

Temperature caused by heat from radiation requires more detailed calculations to ensure the accuracy of the average room temperature value. Although the average radiation temperature can be considered the same as air temperature, the magnitude of the radiation temperature is an important factor in determining the thermal comfort index (Hermawan et al., 2021) (Kaharu et al., 2017) (Nurrahman, 2019).

c) Air humidity

Air humidity is the amount of water vapor present in the air and relative humidity is the ratio between the amount of water vapor and the maximum amount that can be stored at a certain temperature. Several factors that effect air humidity include solar radiation, air pressure, altitude, wind, air destiny, and temperature. Air humidity has an important role in thermal comfort. Humidity that is high or low from the comfort threshold can cause discomfort. High humidity inhibits the release of heat from the human body, so a good wind speed is needed in the room (Willyanto, 2017).

d) Wind speed

Wind speed is the rate of horizontal air movement at a height of two meters above the ground which is influenced by surface conditions and factors such as barometric gradient, location, altitude, and time of day. Wind speed in humid tropical climates tends to be minimal, usually occurring during the day or the changing season. Wind help accelerates the release of heat from the surface of the skin and lifts water vapor which inhibits the release of heat. However, winds that are too strong can create chilly conditions and reduce thermal comfort (Aminuddin et al., 2016) (Fajar and Purwantiasning, 2021).

e) Clothing insulation

Clothing is also a factor that affects thermal comfort. There are several ways that humans can adapt to thermal conditions in the environment, one of which is by dressing. For example, wearing thin clothes in summer and thick clothes in winter. The type and material of clothing worn also affect the release of body heat (Cahyani et al., 2017).

f) Activity

The balance of human body temperature is the basis of thermal comfort. The body tries to maintain a temperature of 37°C and the production and release of body heat must be balanced. Burning food in the body through metabolic processes helps to obtain energy. The activities carried out affect the metabolic rate and as a result the amount of heat energy produced by the body will also increase (Sujannah et al., 2019).

3. THE METHODS

The method used in this research is inductive qualitative. The author conducted a literature review using the terminology of tropical architecture and thermal comfort to obtain the results of an analytical study and wrote inductively. The data taken are primary and secondary data. The primary data includes site visits to expandable house and secondary data obtained from the results of a literature review and comparison of case studies.

4. RESULTS AND DISCUSSION

Expandable house is a house designed to add additional space to an existing house. This expandable house usually has a simple design and shape and can be added or removed as needed. Usually, this expandable house is used to provide additional space for a growing family, or as a living room, work space, hobby room, and others.

The expandable house has a structure that is easy to disassemble and move so that it can adapt to changing needs and land conditions. This house is designed with a minimalist and modern concept, and pays attention to aspects of comfort and energy efficiency. The materials used also take into account climatic and environmental factors, such as the use of materials that are environmentally friendly and easily available in the local area.



Figure 1 : Front view of expandable house
Source : Writer, 2023



Figure 2 : Rear view of expandable house
Source : Writer, 2023

The façade of this expandable house use material consisting of adobe bricks and bamboo as walls, the grilles on the doors and windows use sungkai wood. This bamboo wall use technology from Singapore by using a press machine which ends up being wall panels made of bamboo.

The bamboo blinds that are visible on the front and rear view function as a secondary skin to limit the entry of sunlight, and also help keep the room temperature cool without the need for many artificial cooling system, making it more energy efficient. The terrace of this expandable house has very minimal space because the terrace of this expandable house is only visible in the glass windows that can be opened and closes as needed, and can be used for the user home business land such as selling daily goods, snacks and others.

The roof of the expandable house uses a slanted zinc material because apart from being protector for the house, it also functions to direct rainwater towards the water storage pipe. The roof also has a solar panel that functions to convert solar energy into electrical energy, so that at night can use the panel energy to turn on electricity at home.



Figure 3 : Opening elements in the house :
Glass windows
Source : Writer, 2023



Figure 4 : Opening elements in the house :
Wooden door and bamboo window
Source : Writer, 2023

DOI: <https://doi.org/10.17509/jare.v5i1.55723>

p- ISSN 2776-9909 e- ISSN 2580-1279

The openings in this expandable house have three types of openings. The first is a door made of wood which can help increase thermal comfort in buildings because wood material can reduce room temperature. There are two types of doors, sliding doors, and awning doors. Sliding doors are used for compact spaces such as storage rooms and bathrooms or toilets, to save space for movement. While the awning door is used for the main access door in large rooms. The choice of this type of door is not only to save space for movement but also to provide more or less air circulation and light entering the room.

The second is the opening in the glass window which functions for natural wind circulation on the site so that thermal comfort inside the building is maintained. This glass window is made flexible, it can be closed when the room is cool enough, or opened when the room needs air from outside. The use of glass coverings as a window material can also help incorporate natural light into the living room. However, if at certain times the sunlight is too much, then the bamboo blinds can be lowered to block the excess light from entering the room.

And the third is wooden windows arranged vertically which have woven bamboo panel coverings to provide a thermal comfort effect in the room which can help keep the temperature and humidity in the house stable. This vertical wooden lattice window with sliding bamboo woven panel covering is intended for rooms that are more private and are located close to the hallway or terrace. So that the tight arrangement of wood and woven bamboo can reduce the amount of wind that enters the hallway area.



Figure 5 : Wall elements in the house : Hollow bricks
Source : Writer, 2023



Figure 5 : Wall elements in the house :
Bamboo pressed panels
Source : Writer, 2023



Figure 7 : Roof elements on the house : Fabric
ceiling
Source : Writer, 2023

The expandable house which is the result of research and design by the ETH Zurich Singapore team uses adobe brick material in almost the entire façade of the building. Because this brick material has a durable and stable quality. Whether it's hot or cold, the brick material is customized in shape and arranged in such a way that it has holes in the





wall that serve as natural wind entry and exit. With workmanship and detailed design, these walls then become natural breathable walls so that good air circulation occurs and can make thermal comfort in the house more stable and comfortable.








Some parts of the walls are made of pressed bamboo panels. The bamboo panels are then arranged in a flipper style like the old wooden houses. This method is a local method that has been proven to be able to capture natural air so that the house feels cool. The use of natural materials also serves to increase thermal comfort, because bamboo has cool properties so it can help keep the room temperature cool.

Void stairs from the first floor to the third floor also help increase vertical air circulation. The area on the third floor is an empty area which can later become an additional area for home expansion. Because of its temporary nature, roof ceilings also do not use permanent materials. To reduce heat and stuffiness from tin roofs, cloth is the choice of ceiling material. Fabric can absorb heat and is temporary. In addition, the wavy fabric arrangement adds to the aesthetics of the room.

Through reviewing the location of the expandable house case study, the building elements of contemporary tropical architecture in the city of Batam are obtained. To deepen the identification of building elements, the authors also make a comparison which aims to identify elements in contemporary tropical buildings in general. A comparison was made between the expandable house case study, Batam and the Salman Mosque case study ITB, Bandung.

Table 1. Comparison table of contemporary tropical building elements

Building elements	Expandable house	Salman mosque ITB
Location	Batam	Bandung
Roof	 <p>Angled zinc material.</p>	 <p>Source: Google The concrete material is in the form of no.</p>
Mass composition	 <p>Rectangle.</p>	 <p>Source: Google Square.</p>
Building mass orientation	East southeast to west southeast.	West and North.
Structure	Steel frame grid of columns and beams.	Concrete truss column and beam grid

Building elements	Expandable house	Salman mosque ITB
Location	Batam	Bandung
Ventilation	 <p>Natural (wooden window, stair void, fin bamboo wall, hollow adobe wall) and artificial (fan).</p>	 <p>Source: Google Natural (brick rooster, corridors, roof ventilation) and artificial (fan).</p>
lighting	 <p>Natural and artificial.</p>	 <p>Source: Google Natural and artificial</p>
Landscape arrangement	  <p>Natural vegetation (existing coconut trees) and artificial vegetation (aquaponic).</p>	 <p>Source: Google Natural vegetation (existing shade trees and shrubs).</p>

Building elements	Expandable house	Salman mosque ITB
Location	Batam	Bandung
Material	Bamboo, adobe bricks, and sungkai wood.	Natural stone, roster brick and wood.
Color	The natural color of the material.	Material natural and artificial colors (natural brown and white colors).

Source: Writer, 2023

Based on the results of the comparison table above, the elements contained in contemporary tropical architectural buildings have several similarities and differences in terms of design style processing. Some of the similarities of the two buildings are the mass composition, building structure, ventilation, lighting, and building materials. The mass composition of the two buildings uses massive beam masses with a beam column grid structure. The obvious similarity between the two buildings is that they have natural and artificial lighting from various directions and aspects. Particularity for natural ventilation, although there are differences in the ways and aspects of utilization, both buildings utilize various architectural elements and materials to optimize natural ventilation to increase thermal comfort in buildings.

This aspect is the use of material on the walls. The walls in the expandable house use hot bricks, but are designed and arranged in such a way that they become breathable walls. There are also bamboo panel walls that are arranged in pins and needles to add freshness to the building. While the walls in the Salman ITB Mosque building use natural stone and roster bricks to optimize the cold air in the room. The main ventilation of the two buildings also comes from different architectural elements. The expandable house uses window openings with wooden latticework and woven bamboo as ventilation, while the Salman Mosque uses roof ventilation and high ceilings as the main circulation of natural ventilation.

Even though the architectural elements used in the two buildings are different, the purpose remains the same. That is getting thermal comfort from ventilation and natural lighting from various angles and optimizing the use of natural materials in buildings.

5. CONCLUSION

Residential buildings with contemporary tropical architectural concepts in the city of Batam are still not widely found. The application of this concept was found to be very responsive to the tropical climate of Batam city. There are 9 building design elements, namely roof, mass composition, building mass orientation, structure, ventilation, lighting, landscape arrangement, material, and color. The results of this identification were obtained based on field studies and case study comparisons. In addition to building elements, in designing a residential house with a contemporary tropical architectural concept, it is also necessary to consider several aspects of approach, such as the use of materials, landscape arrangement, and types of openings.

With the identification of elements of contemporary tropical architectural houses, it is hoped that this can become a reference for listeners of tropical architecture to apply existing design elements in building residential houses with contemporary tropical architectural concepts, especially in the city of Batam.

6. REFERENCES

- Aminuddin, J. (2016). Pengaruh Kecepatan Angin terhadap Evapotranspirasi Berdasarkan Metode Penman di Kebun Stroberi Purbalingga. In *Elkawnie: Journal of Islamic Science and Technology* (Vol. 2, Issue 1). www.jurnal.ar-raniry.com/index.php/elkawnie
- Ardiyanto, N., & Hermawan, D. (2020). PENGEMBANGAN KAWASAN PUSAT JUAL BELI DENGAN PENDEKATAN KENYAMANAN TERMAL DI DESA MARON, WONOSOBO. *Jurnal Ilmiah Arsitektur*, 10(1), 1–5. <https://ojs.unsiq.ac.id/index.php/jiars>
- Bambang, R. R., & Sari, Y. (2021). Penerapan Konsep Arsitektur Tropis Pada Bangunan Pendidikan “Studi Kasus Menara Phinisi UNM.” *Journal of Architectural Design and Development*, 2(1), 20. <https://doi.org/10.37253/jad.v2i1.4341>
- Cahyani, D., Kusdinar, Y., & Mardiana, R. (2017). KENYAMANAN TERMAL PADA SARANA OLAHRAGA. In *Jurnal Kepelatihan Olahraga* (Vol. 10, Issue 2).
- Edyas, A., Daming, T., & Syarif, E. (2017). Konsep Arsitektur Tropis pada Green Building sebagai Solusi Hemat Biaya (Low Cost). *Temu Ilmiah Ikatan Peneliti Lingkungan Binaan Indonesia* 6, H033–H040. <https://doi.org/10.32315/ti.6.h033>
- Fajar, P., & Purwantiasning, A. W. (2021). KAJIAN KONSEP IMAGEABILITY DAN PERMEABILITY DALAM PENGEMBANGAN KAWASAN PUSAT KOTA BARU PARAHYANGAN. *Jurnal Arsitektur Zonasi*, 4(1), 21–33. <https://doi.org/doi.org/10.17509/jaz.v4i1.28307>
- Fitriani, R., & Utami. (2022). *Implementasi Arsitektur Tropis Pada Desain Bukaas Fasad Rumah Susun Rorotan Ix Jakarta Utara*.
- Hermawan, Hindaryanto, A., & Taoda, A. (2021). KARAKTERISTIK TERMAL RUMAH BATU EKSPLOS DI TROPIS PEGUNUNGAN (Studi Kasus di Desa Kwadungan , Wonosobo). *Jurnal Arsitektur Zonasi*, 4, 153–166.
- Hermawan, Prianto, E., & Setyowati, E. (2019). The analysis of thermal sensation vote on the comfort of occupants of vernacular houses in mountainous areas of Wonosobo, Indonesia. *International Journal of Advanced Science and Technology*, 130, 33–48. <https://doi.org/10.33832/ijast.2019.130.04>
- Jhon Alfred Depa Dede, P., Masias Siso, S., & Kerong, F. T. (2020). *Pendekatan Arsitektur Tropis Pada Bangunan SMAK Syuradikara Ende*.
- Kaharu, A., Kindangen, J. I., and Intisari, J. O. W. (2017). ANALISIS KENYAMANAN TERMAL PADA RUMAH DIATAS PANTAI TROPIS LEMBAB “Studi Kasus Rumah Atas Pantai Desa Kima Bajo, Kabupaten Minahasa Utara.”
- Mahabella, L. S., Abduh, M., Person, K., Lintang, :, Mahabella, S., Tlogomas, J. R., and Lowokwaru, K. (2019). *Seminar Nasional Teknologi dan Rekayasa (SENTRA) 2019 ISSN (Cetak) 2527-6042 eISSN (Online)*.
- Meiranny, A. (2017). KENYAMANAN TERMAL SELAMA PERSALINAN (Vol. 1, Issue 2).
- Mustamin, T., Rahim, R., Mulyadi, R., Jamala, N., & Kusno, A. (2017). *Analisis Fluktuasi Temperatur Udara dalam Ruang pada Ruang Seminar Laboratorium Sains dan Bangunan Kampus Gowa*.
- Nurrahman, H. (2019). Optimalisasi Desain Fasad Bangunan Restaurant Di Kebonwaru, Batununggal Kota Bandung. *Jurnal Arsitektur ZONASI*, 2(2), 138. <https://doi.org/10.17509/jaz.v2i2.17470>
- Permana, A. Y., Akbardin, J., Permana, A. F. S., & Nurrahman, H. (2020). The concept of optimal workplace in providing a great experience to improve work professionalism in the interior design of PLN Corporate university, Ragunan, Jakarta. *International Journal of Advanced Science and Technology*, 29(7), 3238–3254. <http://sersc.org/journals/index.php/IJAST/article/view/18953>

- Permana, A. Y., Nurrahman, H., & Permana, A. F. S. (2021). Systematic assessment with “poe” method in office buildings cases study on the redesign results of office interior after occupied and operated. *Journal of Applied Engineering Science*, 19(2), 448–465. <https://doi.org/10.5937/jaes0-28072>
- Prianto, E., Suyono and Sahid, B. (2018). *Aplikasi Resiliensi Arsitektur Tropis pada Renovasi Disain Masjid (Studi Kasus Disain Masjid Baitul Hikmah-Losari Brebes)* INFO ARTIKEL. 24–41.
- Saroinsong, F. B., Kalangi, J. I., and Babo, P.(2017). *Redesain Ruang Terbuka Hijau Kampus Unsrat Berdasarkan Evaluasi Kenyamanan Termal Dengan Indeks Disc*.
- Sujannah, H., Munir, A., and Sawab, H. (2019). *Evaluasi Kenyamanan Termal Hana Cafe Darussalam, Banda Aceh*. 3(2), 17–22.
- Syahriyah, D. R. (2017). Penerapan Aspek Green Material Pada Kriteria Bangunan Rumah Lingkungan Di Indonesia. *Jurnal Lingkungan Binaan Indonesia*, 6(2), 95–100. <https://doi.org/10.32315/jlbi.6.2.95>
- Thiodore, J. (2018). *PERANCANGAN PENCAHAYAAN SAMPING PADA ARSITEKTUR TROPIS* (Vol. 2). <http://halibitonganomtatok.wordpress.com/catego>
- TYAS, W. I., NABILAH, F., PUSPITA, A., & SYAFITRI, S. I. (2015). Orientasi Bangunan Terhadap Kenyamanan Termal pada Rumah Susun Leuwigajah Cimahi. In *Jurnal Reka Karsa © Jurusan Teknik Arsitektur I tenas | No.1 | (Vol. 3)*. <https://ejournal.itenas.ac.id/index.php/rekakarsa/article/view/628>
- Widodo, S. (2021). *PERANCANGAN PUSAT KEBUDAYAAN BETAWI DENGAN PENDEKATAN ARSITEKTUR TROPIS DI JAKARTA*. <https://ejournal.borobudur.ac.id/index.php/teknik/article/view/888/813>
- Willyanto, E. (2017). *PENGARUH DESAIN ARSITEKTURAL TERHADAP KENYAMANAN TERMAL BANGUNAN IKLIM TROPIS LEMBAB*. <https://ejournal.sttcirebon.ac.id/index.php/jas/article/view/61>