

Comparative Analysis Study of Building Envelopes between Vernacular and Modern Houses in Coastal Areas of Java against the Wet Tropical Climate in Indonesia

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Abstract

Indonesia is an archipelagic country that has a wet tropical climate. This climate has hot weather throughout the year yet accompanied by high rainfall in certain months of the year. With the climate situation mentioned previously, the choice of material for residential building envelope is crucial for residential architects. Traditional architecture on the island of Java is architecture in which the covering material of a building is made of woven bamboo sheets or wooden sheets parallelly arranged with wooden sticks as the main construction material. Unfortunately, buildings with these materials have been abandoned and replaced with brick structures introduced by colonial influences that colonized Indonesia. Wood and bamboo materials are known as materials that have low thermal lag so that heat transfer can occur rapidly without any delay, hence why they are considered suitable for coastal areas. In this research, the team will prove the advantages and disadvantages of envelope materials based on literature studies on energy efficiency theory and the selection of building envelope materials. From the results of the research carried out, it is a material framework for further research, namely how to use building envelope materials in accordance with their function.

Keywords: residential, envelope material, wet tropical climate

Introduction

Indonesia is an archipelagic country crossed by the equator. Therefore, based on its strategic geographical position, Indonesia has a tropical climate characterized by warm and even temperatures of around 23 Celsius to 30 Celsius. Meanwhile, there is an Asia-Australia monsoon cycle pattern that can provide variations in the tropical climate with high rainfall for six months of the year (Kurniadi et al, 2023).

Based on 2018 - 2020 PUPR data, Java Island is the fifth largest island in Indonesia, located between 6°S-8°S and 105°E-115°E. The climate conditions on the island of Java are a wet tropical climate from west to east, but towards the east the island of Java has low rainfall and temperatures tend to be higher than in the western area.

Geographically, the island of Java is known as an island which is divided into three regions, namely mountainous, lowland and coastal areas. In particular, this research will only discuss architecture in the coastal areas of Java. Coastal areas are transitional areas that have two ecosystems between the lowlands and the sea. Ecosystems in coastal areas are dynamic

ecosystems and have high and varied habitat richness and interactions between these habitats, this is caused by tidal activity, sea breeze and salt water seepage. In the coastal area itself, the air temperature can reach 35 Celsius because it is influenced by the wind blowing from the sea. In the northern coastal area, the temperature is higher than the southern part, so in terms of soil the southern part is more fertile than the northern part (Yonvitner & Yuliana, 2019).

In general, the typology of vernacular forms in the Java region has similar shapes and characteristics, namely square and rectangular shapes with supporting legs like stilt houses in general. Vernacular architecture has the characteristic of adapting to the culture, limitations and advantages of each region. In terms of materials, vernacular houses in coastal areas use wooden construction as the building frame with wall facades made mostly from wooden panels or woven bamboo, and floors made from cement mortar, although previously they only used soil. For roofs, vernacular houses generally use clay tiles (Idham, 2015).

The selection of building facade materials is an important factor in acclimatizing the wet tropical climate in coastal areas. In previous vernacular architecture, buildings used woven bamboo or wooden sheets arranged in parallel. Wood is known as a material that has a small thermal lag so there is no heat storage in the facade and is considered suitable for tropical climates with high temperatures in coastal areas. Over time, the use of wood material changed to red brick, this new material was introduced by the Dutch as colonizers of Indonesia in the 19th century (Idham, 2015). Red brick material has low permeability so it has a higher thermal lag than wood material. However, in the current modern era, the majority of residential buildings already use red brick as the main material for building facades. So, with the research carried out, the teams will compare the weaknesses and strengths of their respective materials, which is expected to become material for a framework for further research in the future.

Method

In this research, the team will use a basic descriptive qualitative approach with the aim of finding general conclusions that can be used for the framework of subsequent research based on a study of several literature sources related to geographic typology, types of vernacular building materials, and current modern building materials. Specifically for the current research, the team will focus on literature regarding residential building envelope materials for the coastal areas of the island of Java. The urgency of the research is to find out suitable casing materials for the current global warming phenomenon.

Result and Discussion

Vernacular and Modern House Architecture

Vernacular architecture refers to a particular community that is based on local culture and develops naturally. Vernacular building materials usually utilize local materials with traditional

construction techniques that refer to the local environmental climate conditions. Locally available materials such as wood, stone, bamboo, and so on. Material availability is usually found within the surrounding environment. These materials usually form roofs using local construction techniques and walls using wickerwork. As it is the case with the shell of a building that use local and natural materials. The designs applied to vernacular houses are often influenced by the local environment and climate. Buildings have windows, ventilation systems to increase air circulation and reduce heat. The shell of a vernacular building usually reflects local culture and customs which have a rigid design but a distinctive ornaments or engravings (Hermawan et al, 2018a).

Modern home architecture emerged due to external influences, as well as a decline in local natural materials which leads to a frequent use of manufactured, modern materials. Modern architecture generally prioritizes function, simplicity, and clarity. This design emphasizes the shape of the space and user activities (Sopandi, 2021). The materials used are usually concrete, steel, glass, and so on. The material chosen is also due to its strength and durability. Modern architecture was chosen for its clean, minimalist and contemporary aesthetic (Macdonald, 2019). In modern house building exteriors, they are usually geometric in shape with the use of glass which creates a connection between inside and outside. However, today's modern homes are equipped with building technology such as air conditioning systems. Materials used in building exteriors are effective in insulating against heat and noise, and have leak-proof and anti-corrosion protection. Apart from that, house designs often explore materials and create buildings with varied structural forms .

Therefore, there are several notable distinctions between modern and vernacular houses, particularly concerning building exteriors and materials. These two residential buildings provide distinct identities, yet serve the same purpose, namely protecting their occupants.

Thermal Insulation in Building Envelopes

Every region in the world has its own way of achieving thermal comfort. Especially for countries with wet tropical climates, they are known as areas with high temperatures between 27 – 30 degrees Celsius throughout the year alternating with heavy rain in several months. There is research that says modern public buildings currently waste a lot of energy for cooling or heating rooms so that active energy reduction needs to be implemented in order to achieve environmentally friendly building designs. Thermal insulation is one of the main steps besides implementing openings to achieve thermal comfort. Thermal insulation is an effort to cool and heat the interior of a building by controlling the amount of solar radiation heat entering and leaving the building. In the list of materials in the following table, there are two passive cooling capabilities, namely heat storage and thermal conductivity, which is the material's ability to

conduct heat. The choice of material does not stop only at the facade of the building exterior but can also be applied to the roof since it plays a significant role in the room's heating and cooling (Hermawan et al, 2018b).

*Table 1. Thermal conductivity and heat capacity in several types of materials.
Source: Idham (2015)*

Material Name	Thermal conductivity (W/mK)	Specific Heat Capacity (Wh/kg K)	Density (Kg/m ³)
Concrete	1.7	0.24	2300
Reinforced concrete	1.28	0.58	2100
Mortal mix	0.93	0.29	1800
Brick	0.5	0.20	1300
Sand	0.4	0.24	1700
Earth	1.4	0.22	1300
Asbestos cement	0.22	0.25	1200
Wood	0.16	0.66	700
Hollow block concrete	1	0.25	1100
Coconut fiber	0.045	0.58	200

Based on the material data shown above, it is found that concrete is less advised for tropical climates due to its similar conductivity and heat-storage capabilities. Bricks, on the other hand, lower ability to store heat than concrete but their conductivity properties are just as low. Wood fiber is highly recommended for tropical areas since it promotes efficient heat storage but its thermal conductivity is relatively low compared to other materials that are often used as building envelopes.

Vernacular Architecture in Coastal Areas

The Java Island is an elongated plain located at the bottom of the Indonesian archipelago. The topography is divided into three parts, namely mountainous areas, lowland areas and coastal areas. In the coastal area, the topographic characteristics between the northern and southern areas are different, namely the conditions in the southern coastal area are more fertile with hilly topographic conditions so that the majority of people work as farmers, while on the northern coast it is drier because the temperature is hotter so some people work as professions. as farmers, especially in the Central Java region.

The southern coastal area on the island of Java has fertile natural conditions and is surrounded by a series of hills and limestone mountains that start from the Sewu mountains. The Southern coastal region also borders directly on the Indian Ocean, hence why the sea waves tend to be high with a strong sea currents (Yonvitner & Yuliana, 2016). Essentially, residential houses built by the inhabitants only use surrounding materials such as bamboo and local Javanese wood. For its own orientation, the residence was initially directed to the South because of the people's ancient belief in Ratu Kidul as the ruler of the South Sea coast. On the walls, vernacular houses utilize wooden panels or woven bamboo with an insignificant number

of openings because bamboo has high permeability so that air can enter through the gaps between the walls, although inevitably, the interior feels gloomy and is unfit for indoor activities. On the roof, the average community uses bamboo construction with clay tiles as a covering. Grass and straw are rarely used for permanent residences (Idham, 2015).

The northern coastal area of the island of Java experiences drier weather with less fertile soil and recurring issues with shortages of water, making the population heavily dependent on rains, however, in the very same northern coastal area, it is the Islamic religion through Wali Songo and the economic center through the Pantura route until the modern era. Vernacular house construction still utilizes wooden columns and wooden panels as walls that can be moved in the interior.

Wood and bamboo facades are the two main materials that are often used in vernacular buildings in the northern and southern coastal areas. Having a low heat capacity so that solar heat radiation quickly enters the interior, it requires a sufficient number of openings. For wood, it is easier to cut and shape to place the openings, unfortunately for bamboo it has its own difficulties, but bamboo has many small holes so air can still enter through the gaps. Apart from that, in vernacular architecture, the interior of the building is not covered by a ceiling but rather directly towards the roof and from the walls themselves, there are small gaps that allow hot air that has circulated in the interior previously to escape from the building (Idham, 2015).

Vernacular architecture on the island of Java, especially Central Java and East Java, is not in the form of stilt-built houses like vernacular architecture in general but rather built directly touching the ground. This is due to the Javanese belief that land represents fertility and prosperity. However, with this system, it leads to the deterioration of wooden walls that are in direct contact with the ground, which is often damp due to the humid climate and frequent rainstorms and flooding in Indonesia. For that reason, in Javanese vernacular architecture, *baturan*, which is namely a man-made mound of land that is deliberately raised with several foundations surrounding the building (Idham, 2015).

Modern Architecture in Coastal Areas

In this modern era, residential buildings are built with red brick and concrete facades with reinforced concrete construction column and various roof materials. Red brick facades were first introduced by the Dutch colonialists and were subsequently used by society, especially the upper class. High thermal capacity construction materials like brick and concrete allow heat from the sun to reach the interior of a structure later in the day, resulting in a difference in temperature between the interior and exterior. However, due to the low permeability of brick and concrete, the interior space frequently experience dampness, therefore getting enough air

sources and an appropriate floor-to-ceiling distance are necessary to allow fresh air to circulate in the room, as well as placing numerous openings in the proper positions (Sopandi, 2021).

Conclusion

Wet tropics is a climate with hot temperatures and high humidity but within a period of six months there is high rainfall to reduce these temperatures. Good architecture is architecture that can acclimatize to the surrounding microclimate. Several points that form architecture, such as choosing a location and determining the direction of a building, are external points of reference that need to be considered. However, in vernacular architecture, people also build houses based on culture, habits and availability of materials. For climate acclimatization in Indonesia, the determining point for user comfort is proper air flow and reducing solar heat radiation for 12 hours throughout the year to reduce indoor heat and humidity which can reduce comfort. Unfortunately, people in the modern era pay less attention to passive strategies for buildings and there is a phenomenon of land shortage because there is too large of a population on the island of Java. Furthermore, people nowadays dislike mildly uncomfortable temperatures and prefer temperatures of around 20 Celsius, resulting in the use of active energy that is widely used in residential homes in the current modern era.

In this research, the team only analyzed vernacular and modern residential houses from several literary sources and found that each material had advantages and disadvantages which were solved using architectural techniques by the community independently without using active techniques. However, further in-depth research is required to determine the accuracy of both heat storage and heat transfer of each material by recording the temperature on the inside and outside walls of the building.

References

- Hermawan, Prianto, E. P., Setyowati, E. (2018a). Studi Tipologi Rumah Vernakular Pantai dan Gunung (Studi Kasus di Kabupaten Demak dan Kabupaten Wonosobo). *Jurnal Penelitian dan Pengabdian Kepada Masyarakat UNSIQ*, 5(3), 259–266.
- Hermawan, Prianto, E., Setyowati, E. (2018b). Analisa Perbandingan Suhu Permukaan Dinding Rumah Vernakular Pantai dan Gunung. *ARCADE Jurnal Arsitektur*, 2(3), 149–154
- Idham, N. C., (2015) *Arsitektur dan Kenyamanan Termal*. Penerbit Andi
- Kurniadi, A., Weller, E., Salmond, J., & Aldrian, E. (2024). Future projections of extreme rainfall events in Indonesia. *International Journal of Climatology*, 44(1), 160-182.
- Macdonald, A. J. (2019). *High Tech Architecture: A Style Reconsidered*. The Crowood Press.
- Sopandi, S. (2021). The Nature of Tropical Architecture in Indonesian Modernism. *Docomomo Journal*, (63), 70–75. <https://doi.org/10.52200/63.A.GBS0QKW3>

Yonvitner, H. A. S., & Yuliana, E. (2019). Pengertian, Potensi, Dan Karakteristik Wilayah Pesisir. In *Pengelolaan Wilayah Pesisir Dan Laut*, 1–39. Tangerang Selatan: Universitas Terbuka