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# Thermal Performance of De'diba Kulong Ruma Bulongan for Residents Comfort

Icha Anggraini[a,*], Ria Wikantari[b], Baharuddin Hamzah[c]

[a]Department of Architecture, Faculty of Engineering, Hasanuddin University. Email: anggrianiichadesign@gmail.com
[b]Department of Architecture, Faculty of Engineering, Hasanuddin University. Email: rwikantaria@gmail.com
[c]Department of Architecture, Faculty of Engineering, Hasanuddin University. Email: baharsyah@yahoo.com

**Abstract**

The Bulungan Stilt House which in local language is called De'diba Kulong Ruma Bulongan has various floor heights of around 30cm, 50cm and 100cm. The difference in stilted floor height is expected to yield different thermal performance that affects occupant comfort. This study aims to: (1) explain the architectural characteristics of De'diba Kulong Ruma Bulongan and the existing conditions of thermal comfort of the occupants, and (2) analyze the effect of the floor height of De'diba Kulong Ruma Bulongan on the thermal comfort based on measurements and occupant perceptions, (3) explain the floor height performance on occupant thermal comfort as a function of climatic and environmental conditions. This research is quantitative, with a survey method using both qualitative and quantitative data. Data were collected through observation, thermal measurements, and distribution of questionnaires to 43 respondents who lived in 9 samples of Bulungan stilt houses. The analysis technique used PMV and PPD through the CBE thermal comfort tools, as well as cross-tabulation of questionnaire data. The results of the analysis of the psychrometric chart and the effective temperature chart at 13:00–14:00 WITA show that the highest average effective temperature in all measured stilt houses is in the range of 25.5-29°C. PMV analysis using the CBE thermal comfort tool shows that houses on stilts are most compliant with Ashrae 55 at a height of 100cm with PMV = 0.02 and PPD feel 5 % of a neutral value with an operating temperature of 25.5 - 27°C. Questionnaire analysis shows the most comfortable thermal reception according to the respondent's characteristics, namely occupants who are women, elderly (> 54 years old), and those who wear long loose gowns called gamis. The analysis of the occupants' perception shows that the most comfortable thermal reception at the four measurement points of the house on stilts is a house on stilts with a height of subsequently 100, 50, and 30 cm. This study concludes that the floor height affects thermal comfort in which the higher the stilted floor height in the architecture of the De'diba Kulong Ruma Bulongan the more comfortable for the occupants. This study also verifies that thermal comfort is influenced by climatic and environmental conditions.

*Keywords:* House on stilts, vernacular architecture, floor height, effective temperature, PMV, PPD, Ashrae 55 2020

## 1. Introduction

The dwelling house is a residential building or dwelling for primary needs which is essentially a place of return, rest, family gathering, sheltered from the scorching sun, rain, and other disturbances which offers comfort and safety to its occupants. The homes of Indonesians are generally adaptive buildings that consume less energy because they depend on the universe, and space efficiency can provide natural comfort for residents. It can be said that the comfort of the occupants of a dwelling house is better if the thermal performance of the space can meet the needs of a dwelling that realizes a safe and comfortable home. One of the indicators for analyzing the thermal performance of residential spaces is very closely related to the condition of residential buildings and the materials used.

*Corresponding author.
*Jalan Poros Malino km. 6, Bontomarannu*
*Gowa, Indonesia, 92171*

The form of local wisdom in the residential building architecture of the Bulungan community also has a legacy of past generations with local values, traditions, and cultural elements rich in local significance. From generation to generation, through trial and error, they have been preserved, giving rise to original works with a philosophy unanimously recognized as a comfortable home with cultural aspects, traditional values, and customs as well as the uniqueness to adapt to climate and environment. Bulungan community dwelling-house architecture has a characteristic in residential buildings, namely on a stage with the main material of wood which can become an icon of the capital of North Kalimantan province, in the Bulungan regency.

Bulungan Regency has a history of a sultanate that once triumphed, namely Bulungan Sultanate which is domiciled in Tanjung Palas. The glory of the Bulungan Sultanate has left a legacy in the form of original values, artifacts, documentation, and evidence in the Bulungan Sultanate Museum. One of its legacies is the richness of

traditional residential architecture with a vernacular conception in the form of a building on stilts developing in the Bulungan community. The physical form of the Bulungan Community Residential Building has similarities with the indigenous people of Bulungan Regency i.e. Dayak Tribe, Bulungan Tribe, and Tidung Tribe i.e. stilt houses.

Regional conditions and features of climatic and environmental adaptation affect the distinctiveness of residential buildings in the form of buildings on stilts. The Bulungan stilt house has a height of 30cm, 50cm, and 100cm on the stilt houses. This Bulungan stilt house is a residential architecture located in Bulungan Regency, the hallmark of this stage is used by residents. According to Bulungan traditional leader Datuk Abdul Hamid, the stilt house in the regional language term Bulungan can be known as De'diba Kulong Ruma Bulongan which means stilt house in Bulungan regency. De'diba Kulong Ruma Bulongan or the stilt house of the Bulungan community has been passed down from generation to generation through a process that the community says has adapted to the climate and environment which refers to a system of passive design to achieve thermal comfort for occupants.

Koppen climate distribution in the Kalimantan region affects the climate and environment of Bulungan Regency i.e. tropical rainforest (Af). This humid tropical climate with tropical rainforests or humid tropics covers the area around the equator characterized by precipitation (rain) and high humidity with almost always high temperatures in summer, little wind, moderate to strong, and little heat exchange due to high humidity in research by Lippsmeier in Sarjono [1]. According to Syafriny [2], in this humid tropical climate, thermal comfort has relatively high air temperature and humidity, causing situations that are sometimes thermally uncomfortable for humans.

The topography of the Bulungan region is also mostly forests and rivers with low soil types or tends to be flat with tidal river characteristics such that when heavy rainfall coincides with river tides, the Residential lands are often affected by flooding. And other conditions that cause thermal comfort problems in stilt houses are climates and environments with extreme weather conditions where the hottest temperature can also turn into heavy rain. High humidity with heavy rainfall causes soil features to be easily wet or waterlogged on the soil surface. On the other hand, he can feel a strong heat with the highest temperature during the day which can cause discomfort.

According to Gross in Angkasa [3], the Benefits of stilt houses include flood protection, maximization of views, expansion of ventilation, aesthetics, and application of sustainability principles. The house on stilts also allows narrow areas to be maximized with the bottom or under the house providing a ventilation function for the floor and the scenography also enhances the aesthetics. The space of the stilt house can be used for activities or to maximize the flow of wind into the house. It can be further classified as a traditional tropical house as a form of response to warm natural conditions to allow residents to get some fresh air in his research Suharjanto [4].

The Bulungan stilt house has different soffit heights ranging from 30 cm, 50 cm, and 100 cm which can also affect the thermal comfort of the occupants. The thermal performance of the various Bulungan community houses on stilts should ensure a comfortable temperature for the occupants. Because the comfort of a home is a psychological need that affects the health of the human mind, feelings, and body.

In addition, the stage form or under it can also be used as a unique or characteristic house in Bulungan Regency, North Kalimantan, which is aesthetically pleasing and suitable for residential purposes. Based on the above description, research is needed to reveal the state of the thermal environment and the level of thermal comfort experienced by the occupants. The results of this study serve as the basis for planning a comfortable stilt house for the residents of Bulungan Regency, North Kalimantan Province.

State of the art in this study we have chosen the case of houses on stilts but there are still few people who research the thermal comfort of houses on stilts under the house which is 100 cm high. This research uses a direct measurement method with a study of the literature. The perception of occupant satisfaction is very important to test the level of thermal comfort in a house on stilts which is strongly influenced by the height of De'diba Kulong Ruma Bulongan which is 100 cm. By using occupant perception to test the thermal comfort of this stilt house, it is hoped that the level of validity or accuracy of the thermal comfort rating can be a standard of measurement in further studies.

Research by A. Sholehah & Wulandari [5], conducted observations on sembau house construction to discover and learn local wisdom values of house construction seen from house layout. With the method of observation and interviews to produce a spatial arrangement in the construction of the sembau house. In further research, R. D. C. Sholehah [6] continued his research on the study of the construction of sembau houses based on the cultural traditions of the community and the elements of the physical system of these traditions and cultures. In sembau house research, the researcher uses sembau house as information about the De'diba Kulong Ruma Bulongan being researched. Wahyudi [7] also investigated thermal comfort in the North Kalimantan region by conducting direct field surveys or observing building shape and the shape of roof openings on longhouses and then taking direct measurements. At several points measuring temperature, humidity, and air movement. According to Soeroto [8], The house on stilts is guided by the traditional wisdom which calls for harmony between the macro-cosmos and the micro-cosmos; and therefore reflects the values of friendship and harmony with nature.

The Bulungan Stilt House in Fig. 1 shows the condition and characteristics of the buildings in the Bulungan Regency area which can be classified according to the height of 30 cm, 50 cm, and 100 cm from the flat ground surface. The house on stilts has similarities with the facade of the building, namely on the porch, the main door, windows, and ventilation (wind) with wide openings. The

main material of the wooden structure. The floors and walls are also made of wood. The thermal performance of Bulungan Stilt House is influenced by climatic and environmental conditions. These thermal conditions can have an impact on the comfort of the occupants.

Figure 1. Location photo of the Bulungan stilt house

## 2. Research Method

The location and research object of De'diba Kulong Ruma Bulongan or the stilt house in Fig. 2 with a height of 30 cm, 50 cm, and 100 cm are located in the regency of Bulungan, in the province of Kalimantan of the North.

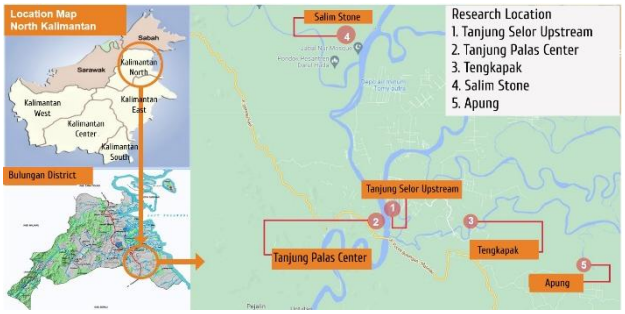


Figure 2. Location of research sites description of the location and purpose of the stage house research

This research is mixed-method qualitative and quantitative with a paradigm of positivism [9]. The data collection technique is based on observation, thermal measurement, and the distribution of questionnaires to 43 samples of inhabitants in 9 stilt houses in Bulungan. The data was then analyzed using PMV and PPD analysis techniques through the CBE comfort thermal tools and crosstab analysis for the questionnaire results.

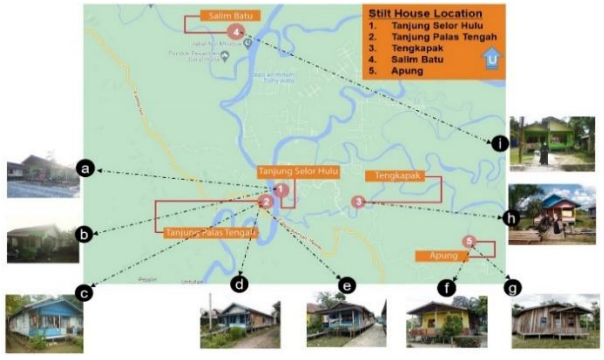


Figure 3. Location of sample stilt house

The researcher took data on the research object of De'diba Kulong Ruma Bulongan or the stilt house in Fig. 3 with direct field measurements in January, February, and March 2022. The conditions and characteristics of this Bulungan stilt house have similarities or similarities with the building facade and space layout. With the height of the stilt houses measuring 30 cm, 50 cm, and 100 cm, the measurements were taken at 1:00 p.m. – 2:00 p.m. WITA (60 minutes) in sunny weather with the measuring instrument used, namely Lutron LM 8000 4 In 1 placed ±80 cm above. The measurements will be compared to the standard Ashrae 55 [10], standard conditions of thermal comfort SNI 03-6572. Meanwhile, the air humidity for tropical areas according to SNI 03-6572-2001 is about 40% - 50%. A good air speed according to SNI 03-6572-2001 is 0.25 m/s with subject comfort and human behavior that adapts to local climatic conditions with the Fanger [11] with parameters based on the perception of air. ASHRAE and Bedford thermal comfort sensation scale [12].

The perception of occupants is the people who live in the house and so on. Architecture is essentially a space or an environment for humans. Dwelling houses are identical to the existence of humans inhabiting them for activities, communicating physically and psychologically as residents. The human as an inhabitant is an integral part of the home, of the intertwined culture and environment by Rapoport [13]. The human relationship with the house is one of interdependence, that is, humans affect the house, and vice versa, the house affects humans.

The adaptive theory assumes that people consciously or unconsciously respond to a given thermal environment in which they are exposed to restore their thermal comfort [11]. The recent development of the adaptive theory of thermal comfort explains occupants' thermal comfort in different environmental contexts, particularly in naturally conditioned buildings, from the point of view of the adaptive approach [14].

Newmark [15] stated that in addition to being a basic need to stay alive, it is also a basic need for security, a symbol of status, way of life, existence, and self-realization of residents. The presence of humans as inhabitants in the process of living or inhabiting creates a space with fully human values such as the behavior of the occupants. Human behavior as a resident greatly determines the quality and form of the house and its environment by Bell, Fischer, and Loomis [16].

## 3. Results and Discussion

### *3.1. Description of condition and characteristics the Ruma Bulungan*

De'diba Kulong Ruma Bulongan or stilt house Bulungan due to its geographical location and topography has a humid tropical climate and is located between rivers, vacant land, and even virgin forest which creates buildings in the form of houses on stilts. Gross in Angkasa [3] concludes that the function of stilt houses is for buildings on loose ground, uneven land contours, river banks, swamps, and elevated areas and can maximize views, extend ventilation from below, add aesthetics, and apply the principles of sustainable development using natural

ventilation and the use of materials found in nature and the environment.

The conditions and characteristics of the De'diba Kulong Ruma Bulongan or Bulungan Stage House have similarities with the facade of the building, the spatial layout is almost the same as the original form of the Bulungan traditional house, and the houses of the indigenous people as a reference for researchers, namely dwelling houses still maintained. "De'diba Kulong Ruma Bulongan" is a Bulungan stilt house that is wide and square extend the rear with a porch on a typical building façade with ample natural ventilation on the main door, windows, and vents that work to catch the air entering the house.

The material of Bulungan stilt houses is wood which has long adapted to the topography of Bulungan Regency. This wooden material comes in the form of ironwood planks on the walls and floors, which helps to maximize the flow of wind through the texture pores on the wooden wall planks and the lower floor planks. The air system of the stilt house can also get good and fresh air inside the house.

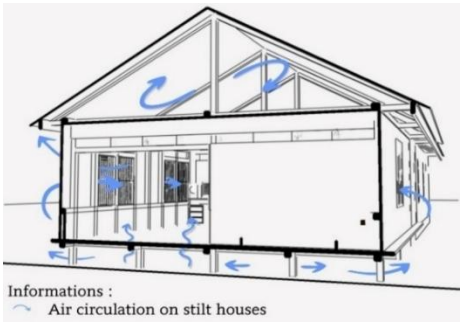


Figure 4. The air circulation system in the stilt house

The high thermal performance of De'diba Kulong Ruma Stage or Stilt House is influenced by the air circulation system or wind flow. Fig. 4 shows that air can flow in and out of windows, doors, and walls, the underside of the house, and turn in the roof openings.

Bulungan Stilt House or De'diba Kulong Ruma Bulongan has a simpler physical building than Bulungan Traditional House, Dayak Traditional House and Tidung Traditional House. According to the researchers' observations, the shape of the Bulungan stilt house is an elongated square without any special ornaments or patterns, colors, or meanings of the original culture or tradition. The three-tribe stilt houses adapt the environment to the space requirements as residential houses, both in traditional houses and De'diba Kulong Ruma Bulongan is believed to adjust the function of stilt houses as flood protection.

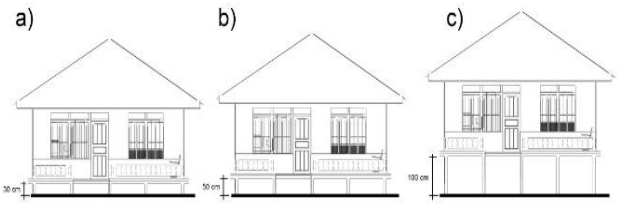


Figure 5. The height of the house on stilts

In Fig. 5, there are variations in the height of De'diba Kulong Ruma Bulongan, which are 30cm, 50cm, and 100cm from the surface of the flat ground having a stilt shape that has adapted to the local environment. According to Datuk Abdul Hamid (2019), the stilt houses functioned according to the livelihoods or needs of the residents, such as wood storage areas, cages, barns, and fishing boats.

The height of the stage is part of the subsoil which adapts to nature, and the environment, and avoids natural phenomena, namely flooding due to the overflow of river water and heavy rain or rain and soil wetting causing waterlogging of the soil surface.

Figure 6. Flooding on the stilt house

Fig. 6 shows that the Kayan River overflows from top to bottom when the river is at high tide and there is heavy rainfall. The high flow of river water at high tide can cross the periphery, drainage enters community settlements, and the tread condition is flat so that water overflows (often) causing of flooding Bulungan stilt houses.

Table 1. Description of research object house on stilts 30 cm high

| No | Existing condition height of the house 30 cm | Information |
|---|---|---|
| 1 |  | The room with door openings, glazed windows, and ventilation left open. Orientation of the Building to the east |
| 2 |  | The room with door openings, glazed windows, and ventilation left open. Building orientation directly to the east |
| 3 |  | The room with door openings, glazed windows, and ventilation left open. Building orientation directly to the east |

However, not only that, the thermal performance house on stilts is expected as a safe and comfortable residence, it must have a good performance for the comfort of the occupants. The thermal comfort from the height of the stilt

house can meet the climate and environment with the right design to avoid flooding at the highest temperature and humidity that can disturb residents so that it can offer thermal comfort for residents.

Table 1 shows that the height of 30 cm on the facade of the building and the opening planes of the doors, windows, and vents differ from houses 1, 2, and 3 in the East and West orientations.

Table 2. Description of research object house on stilts 50 cm high

| No | Existing condition height of the house 30 cm | Information |
|---|---|---|
| 1 |  | Room with doors, windows, and ventilation openings left open. Building orientation facing to the west |
| 2 |  | Room with doors, windows, and ventilation openings left open. Orientation of the building direct to the southeast |
| 3 |  | Room with doors, windows, and ventilation openings left open. Orientation of the building direct to the south |

Table 2 shows that the height of 50 cm has the same spatial arrangement and a different orientation from the sun. Orientation It can be seen on the floor plan which has openings in different directions.

Table 3. Description of research object house on stilts 100 cm high

| No | Existing condition height of the house 30 cm | Information |
|---|---|---|
| 1 |  | Room with door openings, glazed windows, and ventilation left open. Building orientation directly to west |
| 2 |  | Room with door openings, glazed windows, and ventilation left open. Building orientation directly to west |
| 3 |  | Room with door openings, glazed windows, and ventilation left open. Building orientation directly to the east |

Table 3 shows that the height of 100 cm on the facade of the building and the opening planes of doors, windows, and vents differ from houses 7, 8, and 9 in the East and West orientations.

The condition of the flat contour of the land and the ethnic value or the locality of the cultural traditions of the Bulungan people are associated with the stage elements in the stilt houses having the height of 30 cm, 50 cm, and 100 cm. The shape of the wide building extends rearwards according to the needs of the residential space with living rooms and family rooms connected without partitions where the facade of the building has a porch with openings for natural ventilation such as the main, door, windows and winds.

As for the embodiment of the Bulungan architectural building which is always applied to Bulungan regency community houses in Tables 1, 2, and 3, the stilt house building consists of three (3) parts, namely: Uma Ruma, Badan Ruma, Betis Ruma.


Figure 7. Bulungan stilt house division

De'diba Kulong Bulongan house or stilt house as figure 7 shows that there is a division of stilt houses in the Bulungan community. The stilt house division has an arrangement of the buildings of the traditional house in general, namely a traditional house with head, body, and leg elements, as follows:

1. Uma Ruma, namely the head or top of the house as a whole roof-to-ceiling structure (gypsum board);
2. Badan Ruma, namely the body or part of the house from the ceiling, walls, and floors that form spaces with partitions to become living rooms, family rooms, bedrooms, and others as required. The body or part of the wall has many doors, windows, and vents with wide openings to let air into and out of the building;
3. Betis Ruma, which is the foot or step of the house, serves to avoid the overflow of water from the Kayan River, heavy rainfall, and many swampy ground conditions that cause annual floods such as every 2 to 5 years, also protects against wild animals, reptiles and according to the beliefs of the ancient tribes of the interior. to avoid enemy attacks (foreigners), the results of an interview with Mr. Datuk Hamid.

From the results of field observations, it can be analyzed that De'diba Kulong Ruma or the Bulungan Community Stage House has a form of stilt house that takes the philosophy of the traditional forms of Bulungan, Dayak, and Tidung houses as natives of Bulungan Regency more simply without any ornaments or certain features, seen on the facade of the building as well as inside the building. The similarity of the Bulungan stilt

house is that the front of the building has a front terrace that is as wide as the building or part of the width of the building, the wide building extends to the back, all using materials in wood. The main door open and are wide, and the shutters, and ventilation is also wide using wood.

The room has a living room and a family room with wood plank walls with window openings and ventilation in every room. The floor is also made of wood planks covered with plastic carpets by residents. The Bulungan stilt house is a single square building that extbackwardwards. With this type of roofing a zinc covering is used, planar or a building prism. This means that the physical form of the building of the Bulungan stilt house has similarities or similarities, namely that the main material used is the best quality wood, namely Ulin. On the facade of the building there is a wide porch, wide door openings and glass windows. Maximum use of ventilation with openings left open during the day [17]. In the body of the building, the walls and floors are made of wooden planks which are sealed together, then have zinc roofing the with the ceiling and without ceiling, planar roofing and prism roofing or zinc at roofing.

The notable difference is the height of the different stilt houses, namely 30 cm, 50 cm and 100 cm. The different heights of the stilt houses, will affect the thermal performance of the occupants of the circulation of temperature, ventilation, maximum natural lighting entering the Bulungan stilt house from the underside or the floor of the house in wooden planks. De'diba Kulong Ruma Bulongan which was used as a sample of stilt houses in this study was located in the Bulungan community with the criteria of stilt houses having similarities in building facade and spatial arrangement which were distinguished by the location and direction to or orientation of the building.

Bulungan stilt house settlements form the architecture of community houses with the particularity of having stilt house height of 30cm, 50cm to 100cm formed linearly following the early pre-colonial developments, namely Bulungan Sultanate government s It was then consolidated and became the Community Establishments of Bulungan Regency. Settlements were formed based on the Kayan River which was the source of life, transportation, facilities, and infrastructure in pre-colonial times, namely during the rule of Bulungan Sultanate. The residential development pattern develops linearly along the Kayan River and its spreading tributaries, clustering together to form houses on stilts around the river. Because the area is so large and there are still a lot of forests and the population is still small, there are still a lot of vacant land.

The conditions and characteristics of this Bulungan stilt house have similarities in the facade of the building extending to the rear, there is a wide terrace with door openings, glass windows, ventilation using materials in wood with openings that can be opened or closed on a large roof, frames, shutters and wide doors. Conditions and features are close to the river and there are vacant lands and a single building. With t environmental conditions often experience the phenomenon of flooding due to the widening of the river when the river is at high tide.

### *3.2. De'diba Kulong Ruma Bulongan's elevated analysis of thermal comfort variables that significantly affect occupant satisfaction*

#### 3.2.1. De'diba Kulong Ruma Bulongan with a height of 30 cm

The measurement results in Fig. 8 show that the temperature value of stilt house 001 is 1°C lower than that of stilt houses 002 and 003 influenced by the direction facing the facade and the floor plan has a different measuring point aperture.

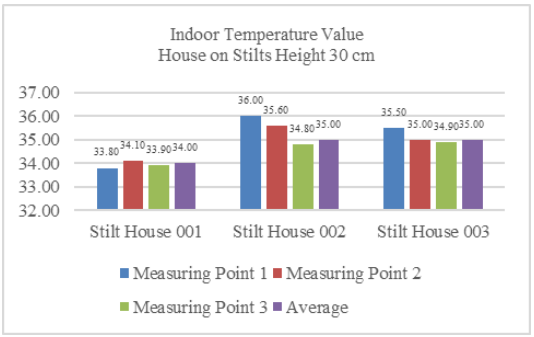


Figure 8. Average temperature value 30 cm high stilt house

The measurement results in Fig. 9 show that the highest humidity value of the stilt house 001 is 1% of the stilt house 002 and 4% of the stilt house 003 is affected by the location near the river.

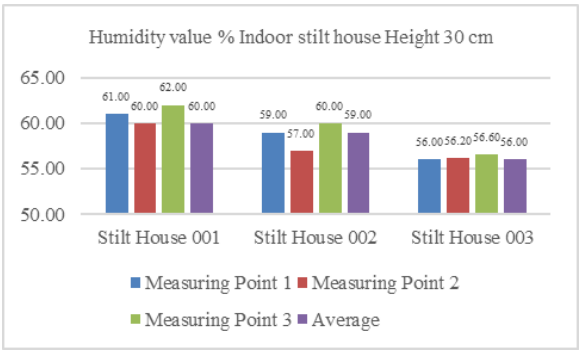


Figure 9. Average humidity value 30 cm high stilt house

The measurement results in Fig. 10 show that the wind speed values for stilt houses 001, 002 and 003 are influenced by location conditions and cardinal directions of airflow in the room of the house. on stilts with a house height of 30 cm. It is not felt because it does not exceed 0.15 m/s or 0.25 m/s.

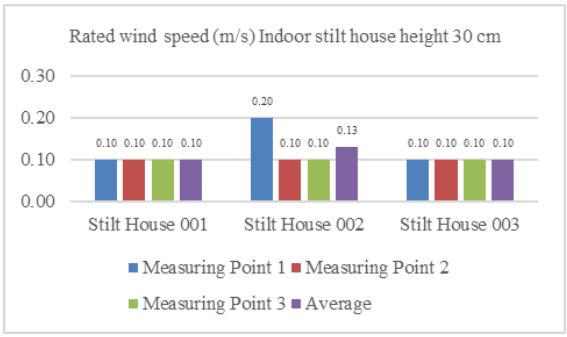


Figure 10. Average wind speed value 30 cm high stilt house

3.2.2. De'diba Kulong Ruma Bulongan with a height of 50 cm

The measurement results in Fig. 11 show that the temperature value of Stage House 005 is 2-4°C lower than that of Stage House 004 and 006 due to the direction of the facade facing the sun with the same layout with different locations. Stilt house 005 is near the river and some trees that affect different outcomes. The 004 stilt houses have openings on the north side but are very close to the river which reflects the heat directly into the house without being obstructed by tall vegetation, as in the 005 and 006 stilt houses which have openings on the south-west side and west, however, the heat of the sun is blocked by the trees on that side.

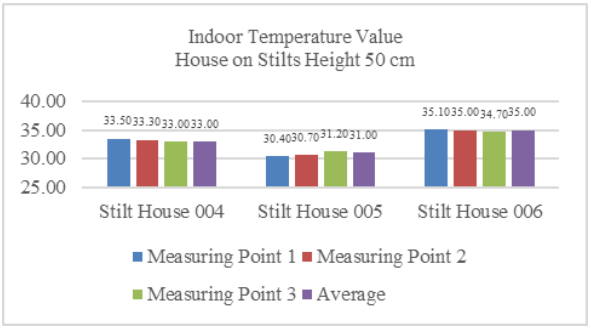


Figure 11. Average temperature value 50 cm high stilt house

The measurement results in Fig. 12 show that the humidity value of the stilt house 005 is 67% higher than that of the stilt houses 004 and 006. in the air of the stilt house.

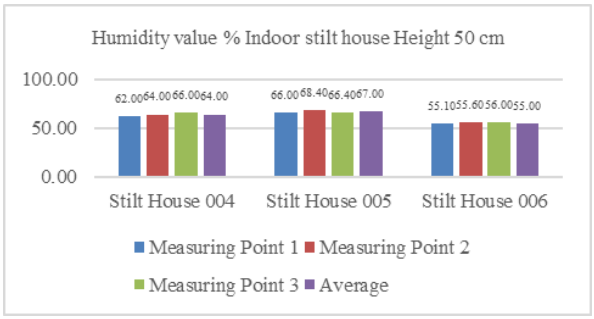


Figure 12. Average humidity value 50 cm high stilt house

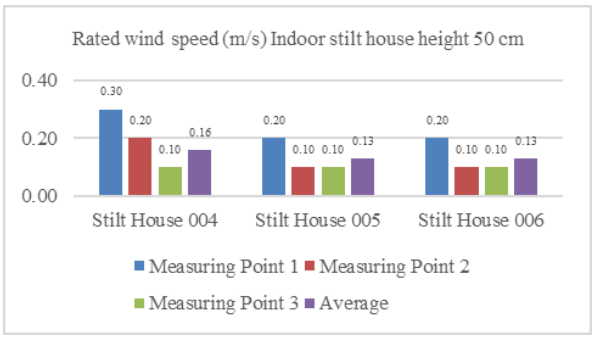


Figure 13. Average wind speed value 50 cm high stilt house

The measurement results in Fig. 13 show that the temperature value of the stilt house 004 is 3°C higher than that of the stilt house 005 and 006 influenced by the direction of the face and the layout of the floor plan. The floor has a different metering point aperture. The 004 stilt houses have an opening on the north side but are very close to the river so that the air enters the house directly without being obstructed by tall vegetation, as in the 005 and 006 stilt houses which have openings on the south side -west and west sides but are blocked by trees on that side.

3.2.3. De'diba Kulong Ruma Bulongan with a height of 100 cm

The measurement results in Fig. 14 show that the temperature values for the Stilt Houses 007, 008, and 009 have the same result of 31°C with the influence of the orientation facing the facade and the layout of the floor plan. floors having openings at different measuring points.

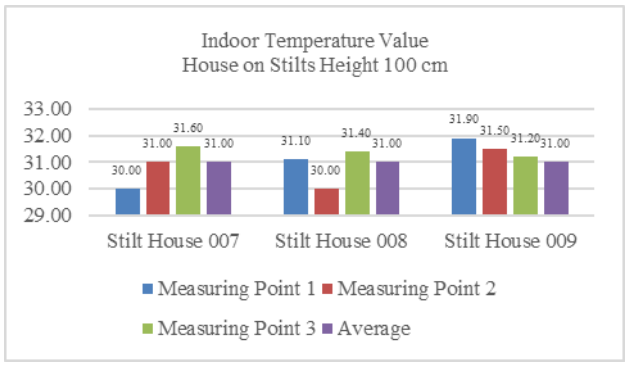


Figure 14. Average temperature value 100 cm high stilt house

The measurement results in Fig. 15 show that the humidity value of Stage House 009 is 5-9°C lower than that of Stage House 007 and 008 due to the direction facing the facade and the layout. of the floor plan with openings at various measurement points.

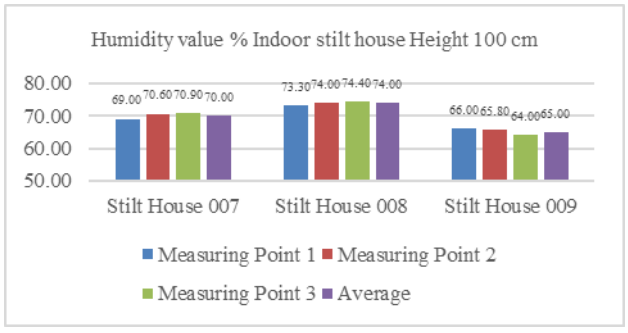


Figure 15. Average humidity value 100 cm high stilt house

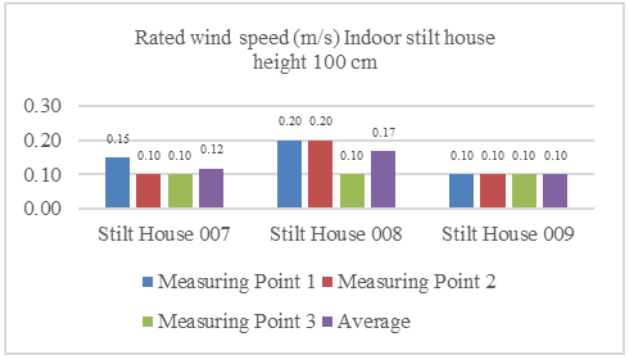


Figure 16. Average wind speed value 100 cm high stilt house

The measurement results in Fig. 16 show that the wind speed of the 009 stage house is 0.10m/s, which is not felt in the room, as well as the 007 stage house and the stage 008 is 0.12 to 0.17 m/s.

### *3.3. Bulungan stilt house effective temperature value analysis comparative results*

#### 3.3.1. Comparison of the average effective temperature of houses on stilts Height 30, 50, 100 cm

Fig. 17 shows that the average effective temperature of a 30 cm high stilt house is 27°C, a 50 cm high stilt house is 28°C, and a 100 cm high stilt house is 28°C - 29°C. The most comfortable thermal condition of a stilt house for residents is a stilt house with a height of 100 cm.

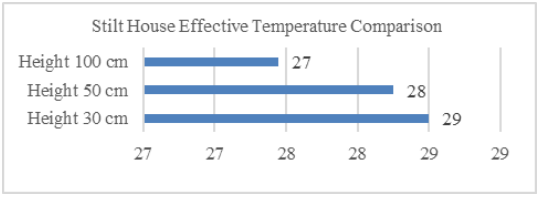


Figure 17. Comparison of effective temperatures of houses on stilts at 30, 50, 100 cm in height

#### 3.3.2. Comparison of the average effective temperature of houses on stilts Height 30, 50, 100 cm

Fig. 18 shows that the average humidity of a stilt house with a height of 30 cm is 58%, a house on stilts with a height of 50 cm is 60% and a house on stilts with a height of 100 cm is 65%. The thermal conditions of houses on stilts for residents, and relative humidity for tropical areas according to SNI 03-6572-2001 is about 40% - 50%. A room with a solid capacity like a meeting room has a recommended relative humidity between 55% and 60%, namely on stilt houses with a height of 30 cm and 50 cm.

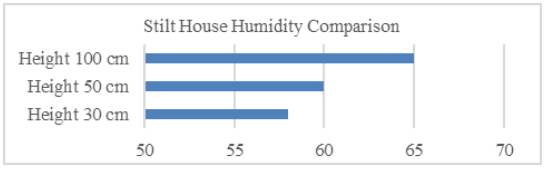


Figure 18. Humidity comparison of houses on stilts with a height of 30, 50, 100 cm

#### 3.3.3. Comparison of the average effective temperature of houses on stilts Height 30, 50, 100 cm

Fig. 19 shows that the average wind speed of a 30 cm high stilt house is 0.11 m/s, a 50 cm high stilt house is 0.13 m/s and a on piles 100 cm high is 0.14 m/s. The thermal state of the house on stilts for residents with the wind speed according to SNI 03-6572-2001 is 0.25 m/s. The airspeed can be made higher than 0.25m/s depending on the dry air temperature conditions in the room. With the highest average effective temperature of all Bulungan stilt houses in the range of 25.5-29°C. So the air pressure is felt as static or airflow which can barely be felt in the room on a stilt house.

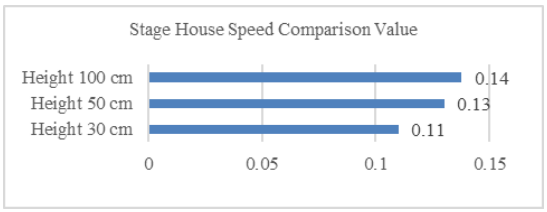


Figure 19. Comparison of wind speeds in a house on stilts at an altitude of 30, 50, 100 cm

### *3.4. Analysis of the thermal comfort of the occupants via the thermal comfort tool CBE (Ashrae 55)*

#### 3.4.1. De'diba Kulong Ruma Bulongan with a height of 30 cm

Fig. 20 shows that the thermal comfort of the measurement data of house 001 on stilts does not respect the Ashrae 55-2020 standard, PMV = 0.83 and PPD = 19% SET = 27.8°C where the individual feels a bit warm.

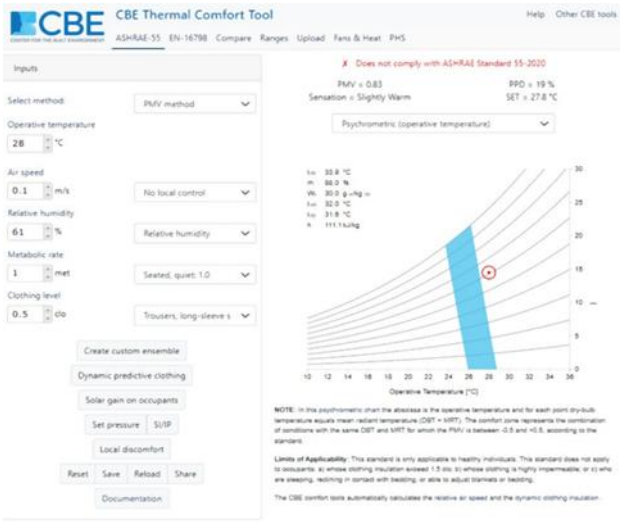


Figure 20. CBE occupant of stilt house 001

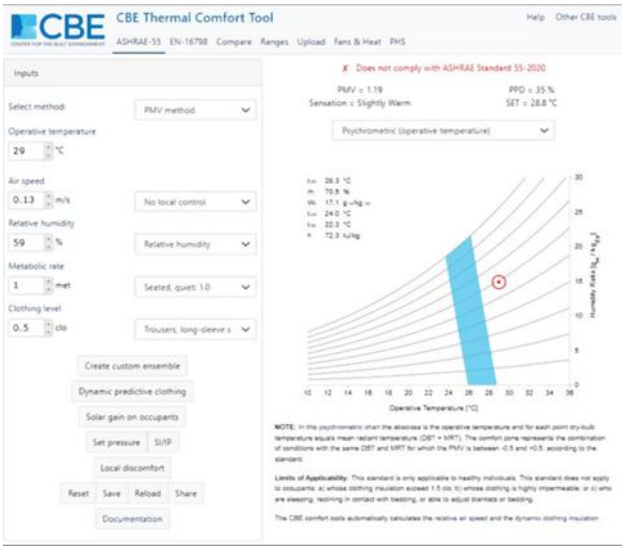


Figure 21. CBE occupant of stilt house 002

Fig. 21 shows that the thermal comfort measurement data of Stilt House 002 does not meet the Ashrae 55-2020

standard, PMV = 1.19 and PPD = 35% SET = 28.8° where the individual feels a bit hot.

Fig. 22 shows that the thermal comfort measurement data for Stilt House 003 does not meet Ashrae 55-2020 standards, PMV = 0.78 and PPD = 18% SET = 27.5° where the individual feels a bit hot.

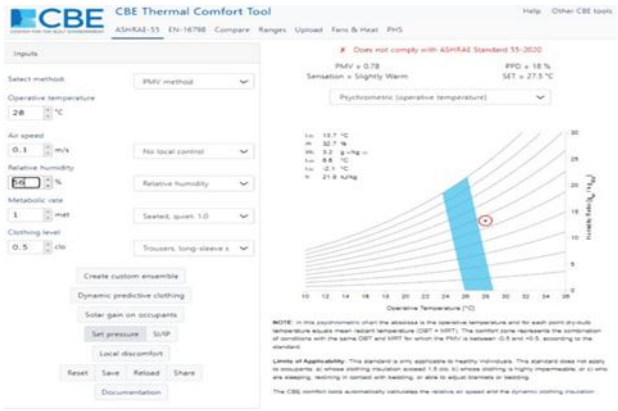


Figure 22. CBE occupant of stilt house 003

3.4.2. De'diba Kulong Ruma Bulongan with a height of 50 cm

Fig. 23 shows that the thermal comfort of the measurement data of house 004 on stilts does not respect the Ashrae 55-2020 standard, PMV = 0.74 and PPD = 17% SET = 27.5°C where the individual feels a bit warm.

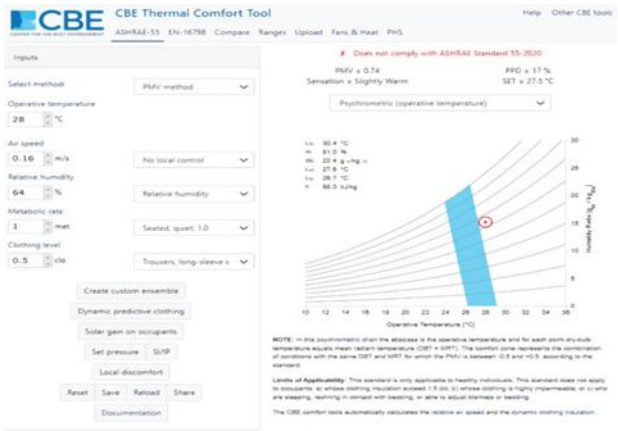


Figure 23. CBE occupant of stilt house 004


Figure 24. CBE occupant of stilt house 005

Fig. 24 shows that the thermal comfort measurement data for Stilt House 005 meets the Ashrae 55-2020 standard with PMV = 0.46 and PPD = 9% SET = 26.6°C, where the individual feels neutral.

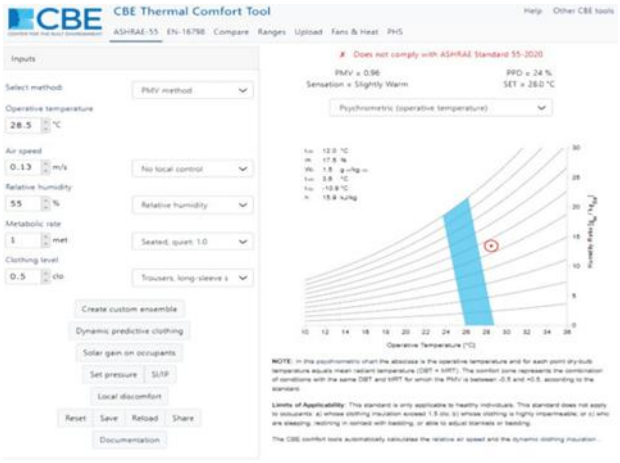


Figure 25. CBE occupant of stilt house 006

Fig. 25 shows that the thermal comfort of the stilt house 006 measurement data meets the Ashrae 55-2020 standard with PMV = 0.96 and PPD = 24% SET = 28°C, where the individual feels a little hot.

3.4.3. De'diba Kulong Ruma Bulongan with a height of 100 cm


Figure 26. CBE occupant of stilt house 007

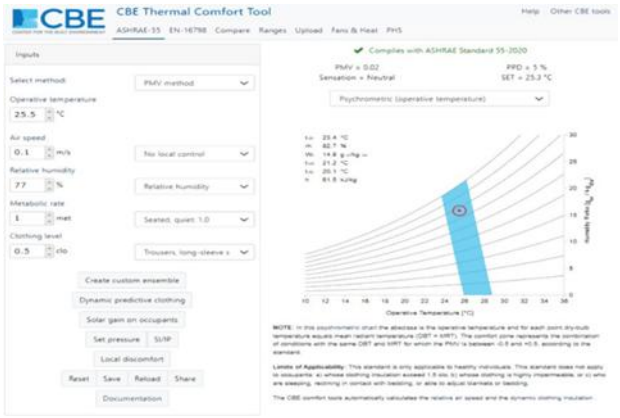


Figure 27. CBE occupant of stilt house 008

Fig. 26 shows that the thermal comfort of the stilt house 007 measurement data meets the Ashrae 55-2020 standard with PMV = 0.46 and PPD = 9% SET = 26.8°C where the individual feels neutral.

Fig. 27 shows that the thermal comfort measurement data of stilt house 008 meets the Ashrae 55-2020 standard with PMV = 0.02 and PPD = 5% SET = 25.3°C, where the individual feels neutral.

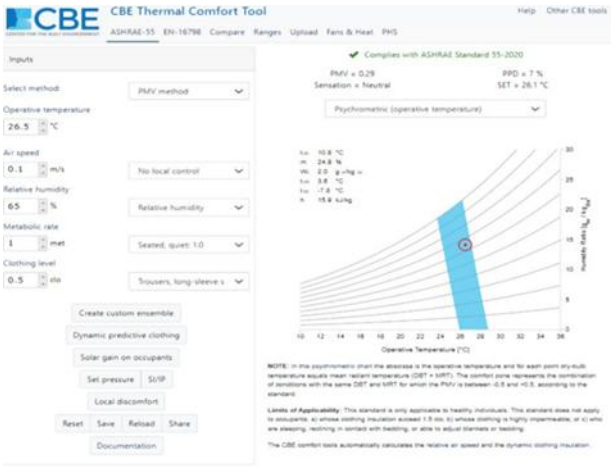


Figure 28. CBE occupant of stilt house 009

Fig. 28 shows that the thermal comfort of the stilt house 009 measurement data meets the Ashrae 55-2020 standard with PMV = 0.29 and PPD = 7% SET = 26.1°C, where the individual feels neutral.

### *3.5. Comparison of average results analysis of thermal comfort measurements according to the Ashrae 55*

#### 3.5.1. The average effective temperature of the stilt house

The average effective temperature of a 30 cm high stilt house is 27°C, a 50 cm high stilt house is 28°C, and a 100 cm high stilt house high is 29°C. The most comfortable thermal condition of a stilt house for residents is in a stilt house with a height of 100 cm.

#### 3.5.2. The average stage house humidity value

The average humidity of a 30cm high stilt house is 58%, a 50cm high stilt house is 60%, and a 100cm high stilt house high is 65%. The thermal conditions of houses on stilts for residents, the relative humidity for tropical areas according to SNI 03-6572-2001 is about 40% - 50%. A room with a solid capacity like a meeting room has a recommended relative humidity between 55% and 60%, namely on stilt houses with a height of 30 cm and 50 cm.

#### 3.5.3. Stage house average wind speed

The average wind speed of a 30 cm high stilt house is 0.11 m/s, a 50 cm high stilt house is 0.13 m/s and a on piles 100 cm high is 0.14 m/s. The thermal state of the house on stilts for residents with the wind speed according to SNI 03-6572-2001 is 0.25 m/s. The airspeed made higher than 0.25m/s depending on the dry air temperature conditions in the room.

The results of the analysis show that the correlation between the measurement results is directly addressed using the effective temperature and in the CBE analysis the thermal comfort tools are compared to the perceptions of the inhabitants of the stilt house at a height of 100 cm with a sense of net worth that can be felt by residents. Air circulation through the opening with the direction facing the opening also affects the thermal performance of the stilt house for the comfort of the occupants. With a height of 100cm, it can meet the thermal comfort standard for a Bulungan stilt house rather than a height of 50 cm and 30 cm.

### *3.6. Thermal comfort analysis based on occupant perception*

#### 3.6.1. Perception of comfort according to the gender on occupant perception

In this case, Fig. 29 shows there are differences in male and female respondents which the acceptance of the thermal conditions of the stilt houses of the female respondents is better than that of the male respondents. Male respondents are hardly too far away from feeling the thermal performance of stilt houses. Based on the measurement point, the highest level of comfort perception is in the living room, followed by the family bedroom and the intermediate bedroom. Meanwhile, the lowest perceived level of comfort is on the terrace of the house.

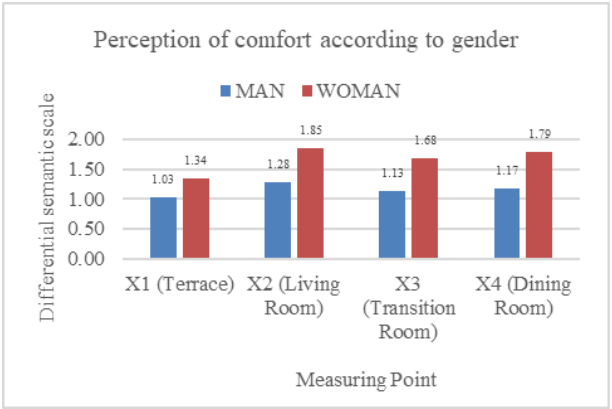


Figure 29. Perception of thermal comfort of occupants of Stage House Bulungan by gender

#### 3.6.2. Perception of comfort according to age on occupant perception

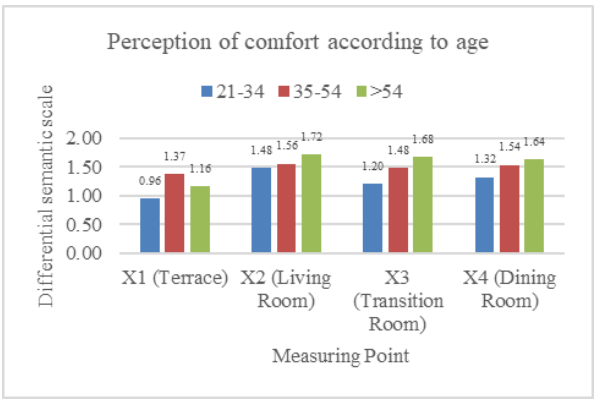


Figure 30. Perception of the thermal comfort of the occupants of the Bulungan Stage House according to age

Based on Fig. 30, shows that the results of the distribution of questionnaires regarding the respondents' acceptance of the thermal conditions of houses on stilts are classified by age at four measurement points, namely the terrace, the living room, the room, intermediate and the family room. The oldest age group (>54 years) shows in this case a better acceptance of thermal conditions, followed by the adult age group (35-54 years), while the lowest level of perception is that of adolescent respondents (21-34 years old). According to the point of measurement, the highest level of perceived comfort is found in the living room, followed by the family room and the intermediate space. Meanwhile, the lowest perceived level of comfort is on the terrace of the house.

### 3.6.3. Perception of comfort based on clothing insulation

The results of the questionnaire in Fig. 31 show that the acceptance of thermal comfort by the respondent according to the type of clothing worn at four measurement points, namely the terrace, the living room, the intermediate bedroom and the family room, the results show that most of the measuring points are at a rather comfortable and comfortable level in the dresses. Judging by the type of clothing worn, Gamis in this case shows the best acceptance of thermal conditions, followed by negligee and batik.

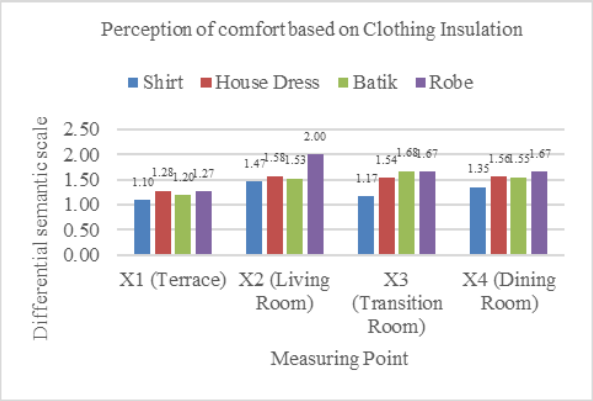


Figure 31. Perception of the thermal comfort of the occupants of the Bulungan stilt house according to the insulation of clothing

The lowest level of perception is that of respondents who wear t-shirts. The gamis is carried by the age group > 54 years where the previous measure shows the highest satisfaction among all age categories. Meanwhile, t-shirts are mostly worn by teenagers whose previous body measurements show the lowest comfort level of all age categories. According to the location of the measurement point, the highest level of perceived comfort is found in the living room, followed by the family room and the intermediate space. Meanwhile, the lowest perceived level of comfort is on the terrace of the house.

### 3.6.4. Perception of comfort based on stage height

Fig. 32 shows that De'diba Kulong Ruma Bulongan or Bulungan stilt house was made by collecting questionnaire data which used as respondents composed of 31 men and 37 women to determine the perceptions of the residents. Occupants of houses on stilts on the based on the results of a questionnaire relating to the acceptance by the respondents of the thermal comfort according to the heights of the floor at four points of measurement, namely the terrace, the living room, the intermediate room and the family room, it was found that most of the measuring points were at a comfortable level, except on the terrace of the house whose height of 30 cm is at a rather comfortable level. The highest comfort perception at 3 (three) measurement points in the house is a height of 100 cm, followed by 50 cm and 30 cm.

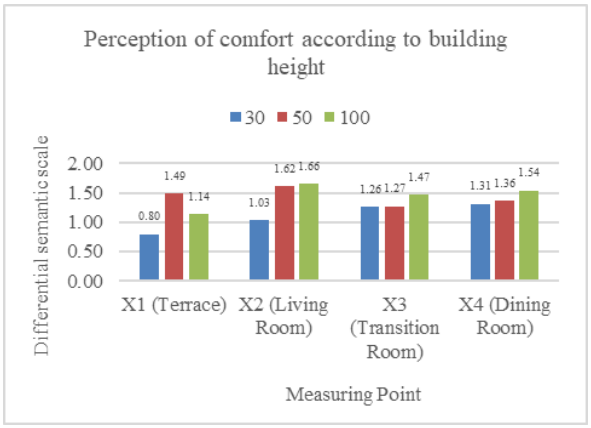


Figure 32. Perception of the thermal comfort of the occupants of the houses on stilts in Bulungan according to the height of the building

While on the terrace of the house, the highest perception of comfort is at a height of 50 cm, followed by 100 cm and 30 cm. Depending on the location of the measurement points, the living room at a height of 50 and 100 shows the most comfortable perception of the occupants, while the terrace at a height of 30 cm shows the lowest perception.

## 5. Conclusion

Based on the results of the study, the architecture of De'diba Kulong Ruma Bulongan represents a traditional stilt house located in a riverside environment surrounded by open land, including community land, forest areas, and uncultivated land. The building orientation generally faces west or east, with a mass composition extending toward the rear and displaying characteristic elements of the head, body, and legs on the façade. The spatial arrangement consists of a terrace, living room, middle bedroom, and family room. The house also features a wide porch, large main door openings, broad windows, and ventilation openings that support natural air circulation. The lower construction system uses wooden supporting poles with floor heights of approximately 30 cm, 50 cm, and 100 cm above ground level.

The findings indicate that the height of the stilt floor significantly affects the thermal comfort of the occupants. A floor height of 30 cm was perceived as uncomfortable, while a height of 50 cm was considered somewhat comfortable or slightly warm. In contrast, a height of 100 cm provided a neutral and comfortable thermal condition for the occupants. The perception analysis further revealed that elderly women experienced the highest level of comfort in the stilt house. Furthermore, the thermal performance of De'diba Kulong Ruma Bulongan is

strongly influenced by floor height, which is closely related to the local climate and environmental conditions. Simulation results conducted over a 24-hour period, particularly during daytime hours from 10:00 a.m. to 3:00 p.m., showed that the house still experienced uncomfortable temperature levels due to high air temperatures, especially between 1:00 p.m. and 2:00 p.m.

## References


[1] A. B. Sardjono, "Respon Rumah Tradisional Kudus terhadap Iklim Tropis," *Modul*, vol. 11, no. 1, pp. 7–16, 2011, doi: 10.14710/mdl.11.1.2011.%p.

[2] R. Syafriny and Sangkertadi, "Perbandingan Pengaruh Suhu Lingkungan pada Kenyamanan Termis di Ruang Luar dan Ruang Dalam di Iklim Tropis Lembab bagi Manusia Beraktifitas Moderat," *Media Matrasain*, vol. 9, no. 1, pp. 26–35, 2012, doi: 10.35793/matrasain.v9i1.668.

[3] Z. Angkasa, "Penerapan Konsep Arsitektur Rumah Panggung di Lingkungan Perkotaan," *Arsir J. Arsit.*, vol. 1, no. 2, pp. 175–183, 2017, doi: 10.32502/arsir.v1i2.880.

[4] G. Suharjanto, "Membandingkan Istilah Arsitektur Tradisional Versus Arsitektur Vernakular: Studi Kasus Bangunan Minangkabau dan Bangunan Bali," *ComTech Comput. Math. Eng. Appl.*, vol. 2, no. 2, pp. 592–602, 2011, doi: 10.21512/comtech.v2i2.2808.

[5] Sholehah, Antariksa, and L. D. Wulandari, "Tatanan Spasial pada Bangunan Rumah Sembau Suku Bulungan di Tanjung Palas, Kalimantan Utara," *J. Perspekt. Arsit.*, vol. 9, no. 1, pp. 8–20, 2014, doi: 10.36873/jpa.v9i01.8945.

[6] Sholehah and R. D. Christyanti, "Tradisi Budaya pada Sistem Fisik Bangunan Rumah Sembau Suku Bulungan di Tanjung Palas Kalimantan Utara," *PROKONS J. Tek. Sipil*, vol. 10, no. 2, pp. 100–108, 2016.

[7] E. Wahyudi, "Pengaruh Bentuk Bukaan Atap Bangunan terhadap Tingkat Kenyamanan Termal pada Rumah Panjang Suku Dayak Brusu Kecamatan Sekatak Kalimantan Utara," *Borneo Eng. J. Tek. Sipil*, vol. 2, no. 2, pp. 94–104, 2018, doi: 10.35334/be.v2i2.617.

[8] M. Soeroto, *Dari Arsitektur Tradisional Menuju Arsitektur Indonesia*, Cetakan 1. Jakarta: Ghalia Indonesia, 2003.

[9] J. W. Cresswell, "Qualitative, Quantitative, and Mixed Methods Approaches," pp. 3–5, 2017.

[10] ASHRAE, "Thermal Environmental Conditions for Human Occupancy," Atlanta, ANSI/ASHRAE Standard 55-2004, 2004.

[11] J. F. Nicol and M. A. Humphreys, "Adaptive Thermal Comfort and Sustainable Thermal Standards for Buildings," *Energy Build.*, vol. 34, no. 6, pp. 563–572, 2002, doi: 10.1016/S0378-7788(02)00006-3.

[12] ASHRAE, *ASHRAE*. Atlanta US, 2017.

[13] M. J. Rapoport *et al.*, "The Relationship between Cognitive Performance, Perceptions of Driving Comfort and Abilities, and Self-Reported Driving Restrictions among Healthy Older Drivers," *Accid. Anal. Prev.*, vol. 61, pp. 288–295, 2013, doi: 10.1016/j.aap.2013.03.030.

[14] G. S. Brager and R. de Dear, "A Standard for Natural Ventilation," *ASHRAE J.*, vol. 42, no. 10, pp. 21–27, 2000.

[15] T. L. Conklin, "Self-Sufficiency Programs in Hampton Public Housing," Virginia Polytechnic Institute and State University (Virginia Tech), 1994.

[16] S. A. Indriyati, "Adaptation Behaviour of Residents Living in a High-Density Housing in Jakarta." Citeseer, 2004.

[17] H. B. Rijal, M. A. Humphreys, and J. F. Nicol, "Development of a Window Opening Algorithm Based on Adaptive Thermal Comfort to Predict Occupant Behavior in Japanese Dwellings," *Japan Archit. Rev.*, vol. 1, no. 3, pp. 310–321, 2018, doi: 10.1002/2475-8876.12043.