The thermal phenomena of Aceh tradisional house due to changes inform spatial planning, building materials and constructure structures

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Abstract. The development of science and technology has influenced the pattern of human life, especially the housing as the basic needs in human life. This can also be seen in the Acehnese people who have made changes to their traditional houses which will unwittingly have an impact on the thermal performance of the building. This study observes the thermal perception of the occupants of the original and changing Aceh traditional houses, in the form of their responses or reactions in describing environmental conditions when the air temperature is hot, normal, or cold, which is carried out by distributing questionnaires. Measurements were made on traditional house buildings and their occupants for 7 (seven) days on each house. As a thermal reference for occupancy, air temperature conditions in buildings and rooms will be measured using a Thermo Hygrograph and a Sling Thermometer. The results of this study indicate that there is a change in the thermal perception of occupancy in the form of a comfort range and length of time when the building is inhabited, which is caused by changes made to the traditional house building, in the form of adding another room at the back without disturbing the main building (Rumoh Aceh) using other materials and different buildings structures (not a stilt house like the main building).

1. Introduction
The Aceh traditional house is a rectangular stilt building that extends from East to West that is made of wood with 16 pillars lined up in four rows A Hajad [1]. Inside the building, there are 3 (three) long rooms, namely seuramo keu which is usually used as a living room; rambat and rumoh ineung which is used as a connecting passage for the two seuramo and utilized as a bedroom; and seuramo likot (back porch) which functions as a kitchen.

Nowadays many Aceh traditional houses have undergone changes made by their residents. The changes consist of adding another room in the back without disturbing the main building (rumoh Aceh) with a different structure and construction (not a stilt like the main building). Building materials used in additional rooms generally consist of concrete bricks and a combination of wood and concrete.

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(semi-permanent). Openings in the form of windows use glass material and some are still using wooden blinds. There are roof coverings that still retain the old material, namely the arrangement of thatch leaves and some are replacing them with other roofing materials in the form of tile or corrugated zinc. Another change made to the Aceh traditional houses is by adding another room without disturbing the main building (rumoh Aceh) under and behind the main building. The material used is also the same.

Several studies from Santosa [2]-[3], L Qadri [4], G Sukowiyono et.al [5], H Razak, et al [6], Q Ayun [7] on building therma that have been carried out in residential areas in humid tropical climates show that buildings using smaller U-value building materials and lower time lag have an impact on better building thermal conditions. The original traditional house building materials use wood as the main material and thatch leaves as the roof covering material. Both of these building materials have a small U-value and low time lag. Meanwhile, traditional houses have changed to using new building materials such as brick concrete, corrugated zinc, and glass, which have a U-value and time lag that is opposite to the original house.

2. Methods

This research is motivated by the thermal phenomenon of occupancy due to changes that occur in Aceh traditional house buildings. The research sample for Aceh traditional houses was taken from traditional houses that were still original and traditional houses that have changed. The occupants of the house as respondents will be taken according to the grouping of the type of house being studied.

After all data regarding the house and occupants are collected, both will be analyzed to obtain conclusions that will explain the impact of house development on the perception and behavior of residents regarding residential thermal. So, the purpose of this study is to find out changes in the perception of residents in interacting with the thermal conditions of their dwellings so that it has an impact on their adapting behavior. The thermal condition of the dwelling is considered as the condition of the dwelling due to changes that occur in Aceh traditional houses.

2.1. Data collection

Observation

Two types of observations were made on the building, namely the measurement of indoors and outdoors thermal conditions. Measurement of the indoor thermal conditions of the building was carried out 24 hours for 7 days on each sample using a Thermo Hygrograph. Which will produce temperature and humidity data. Meanwhile, the measurement of the thermal condition of the room used for daily activities by the respondent, as mentioned above, uses a Sling thermometer which will produce the temperature and humidity conditions of the room when used by the occupants.

While the measurement of thermal conditions outdoor was also carried out simultaneously with measurements of the space used by residents 3 times a day for 7 (seven) days. Measurement of this condition is carried out using a Sling thermometer which will produce data about the temperature and humidity conditions of the outdoor building. Data on outdoor environmental conditions in the form of temperature, humidity, wind speed, radiation, and rainfall conditions were obtained from BMKG Blang Bintang.

Observations made to residents are to observe and record behavior due to perceptions of residential thermals carried out in the face of room thermal conditions at the time of a critical temperature difference in one day. Which occurs at sunrise, that is around 06:00 a.m, the sun position is above the head around 12.00 p.m and at sunset at 7.00 p.m, regarding the questionnaire questions.

2.2. Distribution of Questionnaires

This questionnaire is structured in the form of questions that are read to the respondents, regarding the answers that is felt and carried out by building occupants at the time the measurements or questionnaires were distributed. The time of distributing the questionnaire was carried out 3 (three) times a day at sunrise which is around 06:00 a.m, the the sun position is above the head at around
12.00 p.m and sunset at 7.00 p.m. This is done because at these times there are differences in critical thermal conditions (Santosa, 2003). In each sample, measurements were carried out for 7 (seven) days. The system for filling out the questionnaire was done through direct interviews with questions read from the questionnaire.

3. Results and discussion

Original Aceh Traditional House

The definition of the original traditional house in this study is the Aceh traditional House saboh ineung house (one bedroom) with the shape, spatial arrangement, structure, and construction as well as the materials used are still like the original traditional saboh ineung buildings in general. The shape of the house is as shown in the following picture:

![Figure 1. One room Aceh traditional house (Saboh Ineung).](image)

The building material used for the walls and columns is wood, while the roofing material uses thatch leaves. The existence of translucent carvings on the walls of the building as well as the distance between the parts of the betel nut used on the floor and the holes that occur in the connection boards or openings in the walls that occur due to weather that is not repaired by the occupants can act as pseudo ventilation to allow the occurrence of influential wind infiltration to the thermal conditions of the dwelling. Both of these buildings do not use a ceiling so that the roof frame is visible.

3.1 Transformed Aceh traditional house

Changes made by residents in Aceh traditional houses carried out at the research location by:

a. Keep maintaining the condition of the main house's existing form
b. Does not maintain the condition of the main building's existing form

In this study, observations of Aceh traditional houses changed as shown in point (a), namely changes that still maintain the condition of the existing form of the main building. The changes made were by adding another room at the back as shown in Figures 2 and 3, with a different structure and construction (not a stilt like the main building).

The building material in the additional room uses concrete brick and a combination of wood and concrete (semi-permanent). The material for window is glass with blinds jalouse. Some roof coverings still retain the old materials while some replace them with tile or corrugated zinc.

The building orientation has changed at the main entrance from the south side to the north side. The front porch is still maintained as a living room, the back porch has changed its function into an ironing room and sleeping room. The service area moves downstairs by adding a new room at the back and not on a stilt. To connect the two rooms, an additional staircase is added that is located on the south side parallel to the position of the main staircase.
The main building forms and materials, in principle, have not changed much, except for the interior. The front porch and rambat are maintained, the back porch is made into two rooms, one of which functions as a bedroom so there are two the bedroom in the main building now. The service area was also moved by adding a new room at the back and not in the form of a stilt, connecting the two buildings with an additional staircase on the north side on the back porch and not parallel to the main staircase. The material used for additional buildings on the outside uses permanent concrete walls. There are Venetian blinds on the south and west sides of the building. The wall material in the interior of the additional building uses semi-permanent brick walls while the floor material uses cement plaster. The wall material in the interior of the additional building uses semi-permanent brick walls while the floor material uses cement plaster.
In a humid tropical climate, outdoor temperature conditions are lower than indoor [1]. In addition to the influence of different building designs, it is also caused by the temperature conditions of the outside environment that move up so that it has an impact on the high thermal conditions inside the building. At this time, the wind speed conditions also increased to 2.7 m/s, but these conditions are not able to make a significant contribution to transformed traditional buildings so that the temperature conditions remained high and could not keep up with the temperature in the original building.

Santosa [2], states that the use of materials, spatial arrangement, and the condition of the density of the building environment will have an impact on the thermal conditions of the dwelling. The original traditional building materials, as explained above, use boards for the walls of the building and the arrangement of thatch leaves for the roof. The main building of the traditional house is still using boards for the walls and in additional buildings using concrete bricks. Information on the materials for these two types of buildings can be seen in table 1 below.

| House Building         | Building Materials    | U-val (W/m2K) | Tlag (hour) |
|------------------------|-----------------------|--------------|-------------|
| Original Traditional   | Board                 | 2.14         | 0.60        |
|                        | thatch leaves         | 0.93         | 1.60        |
|                        | 2-sided plaster brick | 1.83         | 4.63        |
|                        | Board                 | 2.14         | 0.60        |
| Traditional Modified   | Glass                 | 5.30         | 0.76        |
|                        | thatch leaves         | 0.93         | 1.60        |
|                        | zinc                  | 6.40         | 0           |

Original traditional house wall and roof materials have heat transmittance (U-value) which indicates that the heat entering through the building elements will slowly propagate into the building so that the wind with an average speed of 1.5 m/s at this time causes a slow time lag through this material then the incoming heat will be reduced because most of the heat will be evaporated.

The placement of windows in traditional houses that change that is not in the direction of the wind affects the obstruction of wind infiltration into the building, while the original traditional house has many openings, one of which is on the floor of the building made of betel nut splits which have a distance of 0.5 – 1.0 cm from each other which is always open to allow for wind infiltration into the building.

Based on the thermal conditions of the dwelling, the building occupants were asked about their perceptions. The answer choices for the questionnaire in perceiving environmental conditions are the comfort range category "hot, cold, and ordinary (not feeling hot and cold)". This comfort range is
determined because at the initial observation this category is more familiar to residents in perceiving their environment.

The category of occupancy thermal perception responses of the two groups of occupants did not differ, consisting of ordinary and cold categories. The tendency of the feeling of the inhabitants of the original traditional house in perceiving the condition of the house is in the category of "cold and ordinary that is felt (not hot and not cold)". Meanwhile, residents of transformed traditional houses described their perception of the thermal conditions of their homes with a tendency to feel "ordinary (not hot and not cold)" which is very dominant from the cold feeling they feel.

This shows that due to changes made by residents in their traditional houses, it has an impact on them in perceiving the thermal of their dwellings with the categories described above. Follow-up questions about what they feel in the house so that the feelings with the ordinary and cold categories in the original and changed traditional houses are divided into as shown in table 2 below.

Table 2. Occupants feelings on the thermal condition of the building.

| Thermal Condition | Thermal Comfort Category | Traditional House Resident (Amount) |
|-------------------|--------------------------|-------------------------------------|
|                   |                          | Original | Transformed |
| Usual Condition   | Comfortable              | 15       | 9           |
|                   | Ordinary                 | 5        | 25          |
|                   | Uncomfortable            |          | 3           |
| Cold Condition    | Comfortable              |          | 6           |
|                   | Ordinary                 |          | 2           |
|                   | Uncomfortable            |          | 16          |

Residents of transformed traditional houses with a temperature range ranging from 22.6 – 29.2 °C perceives the thermal conditions of their residence with the usual feeling of being "comfortable, ordinary (not hot and not cold) and uncomfortable". Some residents perceive cold conditions to be "ordinary (not hot and not cold) and uncomfortable". Feelings such as those mentioned above show that perceiving an environmental condition is a step in interpreting an environmental condition (setting). At the time the measurements were taken, the occupants were doing their daily activities by using different rooms, different clothes worn and different health conditions, therefore the heat dissipation carried out to achieve balance with environmental conditions would not be the same.

Figure 5. Comfort times in an original and transformed traditional house.
Figure 5 shows the comfortable times in both types of houses according to the residents' perceptions. The comfortable conditions of the occupants of both types of houses in the first 2 hours look the same but at later times they start to differ (the thermal conditions of traditional houses change higher) making the comfortable times of transformed traditional houses cannot be fulfilled in the range of occupant’s comfort perceptions, but the comfort of the occupants of both types of houses tends to be the same from 15.00 to 24.00. The humidity condition of the original traditional house is 83% while the transformed traditional house is 90.5%. The average outdoor temperature when residents feel comfortable is 26.1°C with an average wind speed of 1.8 m/s.

The original traditional house feels comfortable for its residents starting at 06.00 to 24.00 with a comfort range of 26.2 – 27.9°C. After this hour, the thermal condition of the dwelling is no longer comfortable and residents perceive the condition of their dwelling to be cold. There are two comfortable periods in transformed traditional house, which occurs from 06.00 am to 12.00 noon. The second period occurs from 15.00 to 24.00 with a comfort range of 26.8 – 28.5°C. After this time they tend to perceive the thermal conditions of the dwelling with normal conditions (not hot, not cold).

Residents of traditional houses have a habit of being out of the house starting at 07.00 and will be at home again from 12.00 to 14.00, then leave the house and be in the house again around 17.00. Based on the tendency to stay at home, the comfortable times occupied by the two types of traditional houses can be seen in the following table.

| Building                     | Convenient Time (AT) | Time (Hours) |
|------------------------------|----------------------|--------------|
| Original Traditional House   | 06.00-07.00; 12.00-14.00; 17.00 -24.00 | 13           |
| Transformed Traditional Houses | 06.00-07.00;12.00; 17.00-24.00 | 11           |

In the table, it can be seen that the comfortable conditions for the original traditional house to live in are longer than 2 hours. This is due to the perception their comfort range is 2 or higher, thus impacting the amount of comfort time that falls into that range.

After obtaining the values of the thermal conditions in both types of houses and the occupants' perceptions of their occupancy conditions, the next step is to look at the behavior of the occupants in responding to these conditions. What is meant by behavior is the tendency or willingness of a person to behave in a certain way when he faces a certain stimulus. Stimulus and response are basic concepts to explain a symptom of behavior that can only be defined and measured physically and significantly Wirawan [8].

4. Conclusion
The results showed that there was a change in the thermal conditions of the occupancy felt by the dweller. This is also shown by the results of measuring the thermal conditions of the occupancy using a thermal measuring instrument. The thermal comfort inhabited by Aceh traditional housess has also changed over time, where the comfort of living in original traditional houses is longer than the transformed traditional houses.

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