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To cite this article: Widya Fransiska F Anwar <sup>1</sup> 2019 *J. Phys.: Conf. Ser.* **1198** 082029

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# The Building Performance of *Limas* House; Dealing with Current Context

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**Abstract.** The *limas* is one of the traditional building typologies in Palembang, the capital of Southern Sumatera Province, Indonesia. Currently, *Limas* is facing challenges due to change on social culture as well as the climate. This study aims to find out the performance of *limas* related to its capability in accommodating the changes of user activity and the climate. In order to achieve this aim, the study measured the thermal and visual performance of three *Limas* houses that are still used as place for living along as working area. Data were collected by field measurement and interview. The thermal and visual performance is observed by the building form, materials and openings. Analysis is done by using thermal and visual comfort simulation. The result is compared to the physical changes of *limas* buildings. The comparison shows layouts changes to fulfil the space needs for current activity. In general, the building performance of those three *limas* accommodates the user's activity in current context but need some improvements for thermal and visual comfort. Paper suggests some actions of *limas* conservation that is responsive to climate and in accordance with user behavior.

## 1. Introduction

Over the years, traditional buildings reliability and existence always become a source for architectural learning. The local knowledge and wisdom might become the filter for modern architectural practice [1]. The used of local material and harmonization with the surrounding environment produced an adaptive architecture that well-suited with user behavior in the past time. The climate, rising temperatures and changes in lifestyle threaten this cultural heritage to its places and value [2, 3]. Therefore, in the conservation effort, it is necessary to pay attention to the effects of climate change on the durability of traditional buildings

*Limas* is one of the traditional building typologies in Indonesia. It is well known as regional identity and easily found in Palembang, the capital of Southern Sumatera Province. *Limas* house have stilt wooden structure and most of them are over 50 years old. Now, *limas* house is facing challenges due the change of climate and user's social culture. Climate change meant here is the increase in surface temperature due to the increasing physical city development. Change in social culture is the lifestyle of current inhabitants that is different to the ones who lived in the past. In fact, *limas* still accommodates the activities of its users in current context. This paper assuming that the change on climate and culture lead to the change of the house, spatially and physically. Those changes will reduce the authenticity of the traditional value of *limas* if they are not well anticipated. Therefore, it is a need to find out the performance of *limas* related to today's climate issue and its capability in accommodating the changes of user behavior.

In order to achieve this aim, the study measured the thermal and visual performance of three *limas* houses that are still used as place for living and working. The observed *limas* were more than 50 years



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old. These houses are still used and not abandoned. The measurement of *limas* included the dimension of the house, room and openings. The data from field measurement was analyzed by using thermal and visual comfort simulation.

## 2. The Architecture of *Limas*

Basically, *limas* is a traditional architecture house. As a place for living and social gathering, its length reaches up to 30 meters. Physically, it is built on the stilt structure, wooden panel and pyramidal roofs [4]. The specific characters of *limas* are the ornament on the roof named *simbar* and the split level at its main room named *kijing*. Some luxurious *limas* have wooden carving or paintings at their ornament and were owned by privileged family.

The spatial arrangement of *limas* follows a specific ordering system. The public zone starts from the terrace named *bengkilas bawah* (*bawah* means under) with a vertical transparent panel named as *pagar tenggalong*. The main room of the *limas* house is the *bengkilas tengah* and *bengkilas atas* (*tengah* mean middle, *atas* means upper). The levels between *bengkilas* are different. This difference or split level is known as *kijing* or *kekijing*. The dimension of split level is 15 to 40 cm of each *kijing*. At *bengkilas atas*, there is a room called *jogan* as guest room or working room. *Bengkilas* with its *kekijing* is a public space that is flexible in its use. The *bengkilas area* is the main room of the house that function as place for social such as family gathering or ceremony. This room serves as a living room in regular day. When there is an event, the *kekijing* become sitting area for the guests. The highest level at *bengkilas* is the sitting area for distinguished or person with higher status. The private area begins at *gegajah*. *Gegajah* room is between the bedrooms (named as *pangkeng*) that has same level with *bengkilas atas*. The back of the house is the semi-private area, named as *pelimpahan* which has similar function as family room. This room is connected to service area. The service area consists of kitchen, food processing room (named as *pawon* and *garang*) and wash room (named as *beraes*). Figure 1 show the architecture of *limas*.

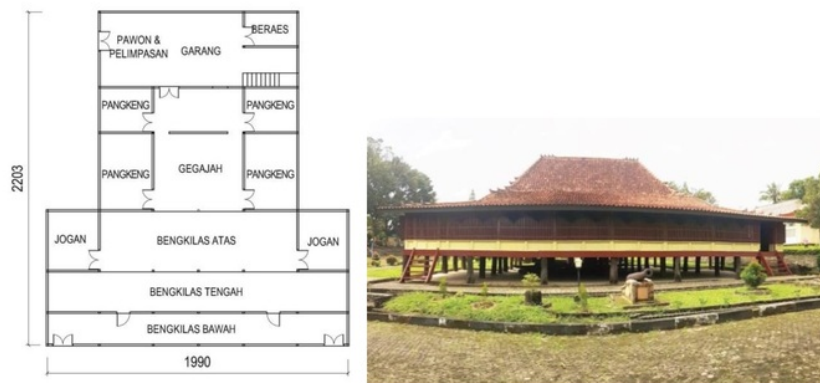


Figure 1. The generic architecture of *limas* house

## 3. The building performance of traditional buildings

Traditional building is rooted from the idea of vernacular architecture. The vernacular architecture emphasizes on the local construction using local natural resources to produce original local architectural works as a reflection of the culture, history and environment [5]. It is the local genius that is well adapted to the local climate. The building performance of vernacular architecture was in accordance with the life of past people. As the climate and social lifestyle are changed, the performance of traditional building in current context of life is questioning. The unsuited performance leads to the action to manipulate or change the architecture of the traditional building and further threatens its authenticity.

Building performance shows the sensitivity that can change the environment, inside and outside the building. The changes are resulted from the uncertainty scenarios of nature and user behavior or lifestyle [6]. By concerning the user behavior, building performance becomes an evaluation of understanding the

design solution that meet user's requirement [7]. It is a further understanding on design adjustment for better internal environment [8].

The traditional building creates physical comfort to its users. In some cases, the traditional have good thermal performance throughout the years caused by its spatial layout and proven by calculation. [9]. They also can create a good thermal and visual comfort from proper building orientation, adequate number of openings, suitable local materials and proper opening placement for natural lighting [10]. Traditional buildings also apply the low energy design principle by natural ventilation, orientation, form and solar shading [11].

#### 4. Measuring the performance of traditional building

Traditional residential area is categorized as built heritage that must be sustainable economically, socially and environmentally. Measuring the environment performance of traditional building enables conservation efforts to achieve the sustainable built heritage conservation [12]. There are two aspects in measuring the building performance; the tools and the user of the building. There are many tools such as computer programs that can be used for measuring building performance. The tool should meet the objectives of practices of the study [13]. Users' behavior determines the physical comfort performance of the building through the way they move and use the space in the building. Users have the ability to control the use of space in buildings to improve the performance of inner space conditioning such as temperature, air quality, lighting and even noise [7]. The ability of users to control the use of space make user behavior become the determinant of optimal building design, both in terms of convenience and use of energy [14]. User behavior is used to predict the performance of buildings especially for the purpose of saving energy and efficient simulation [15, 16]. User behavior can be assessed as culture, presence-action-interaction and satisfaction. Culture reflects the user behavior. User action in using light form 8 am to 8 pm is considered as user presence and action, while the difference action in using 5m<sup>2</sup> office plan for two or one user is considered as user interaction [13, 17]. Users' satisfaction with the utility system or building appearance determine the performance of the building [18,19]. Besides those ways, there are also some measurable parameters had been used for assessing user behavior such as average indoor temperatures, average usage of perceived ventilation from user behavior of different characters [6].

#### 5. Methodology

There are three *limas* houses being observed in this study. All of them are still used as place for living along as working area. Data were collected by field measurement and interview. The thermal and visual performance is observed by the building form, materials and openings. Analysis is done by using thermal and visual comfort simulation. The result is compared to the physical changes of *limas* buildings.

#### 6. Result and Discussion

All of three observed objects are almost 100 years old and still used by the heirs of the first owner of the house. The first *limas* is owned by the family of Mr. Muhammad. The second one is owned by Mrs. Wak Da. The last one is owned by Mrs. Kikin. These three *limas* are located at 7 district Ulu, Palembang. The location is near the Musi River and Kenduruan River, one of old area in Palembang. The *limas* of Muhammad dan Kikin are facing the southwest while *limas* of Wak Da is facing north east (Figure 2).

##### 6.1. The spatial layout and current use of the observed Limas.

The *Limas* of Muhammad is 9.26 meter in width and 16.3 meter in length (Figure 3). The house is facing the village path, oriented to the southwest. The owner did the renovation by adding the kitchen and bathroom at backside of the house. Renovation did not cause any significant change to the *limas* shape of this house. The house is used as a living place as well as a clothing store. The layout of the house is still same as the generic plan of *limas* house, except one of bedroom (*pangkeng*) was removed. From the interview and field observation, the rooms that has opening are the *bengkilas bawah* (terrace), *bengkilas tengah*, *bengkilas atas* (main room) and three *pangkengs* (bedrooms). Each room is equipped with artificial lighting for day and night usage. The electric fans are found in the bedroom and the main room.

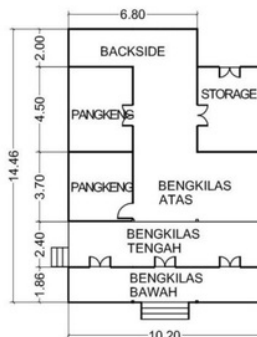


**Figure 2.** The location of *Limas* Muhammad (1), *Limas* Wak Da (2), *Limas* Kikin (3)

The *limas* of Wak Da and *limas* of Kikin are located next to Kenduruan river, a tributary of Musi River (Figure 4 and Figure 5). *Limas* of Wak Da is 10.2 meter in width and 14.46 meter. This has no additional room. The spatial layout is similar to the generic layout of *limas*. Therefore, this house still has *limas* appearance. The change was found in spatial layout. Due to the business of wedding organizer and rental caterer utensil, two of bedrooms are changed. One becomes the storage of equipment and the other one was merge with the living room. The rooms that have openings are *bengkilas* (main room) and *pangkeng* (bedrooms). The *bengkilas bawah* (terrace) is opened since the *pagar tenggalong* (transparent wall) has been removed. Rooms are equipped with artificial lighting for night usage.



**Figure 3.** The plan of *limas* Muhammad.



**Figure 4.** The plan of *limas* Wak Da



**Figure 5.** The plan of *limas* Kikin

*Limas* Kikin is the smallest one among the three observed *limas* (Figure 5). It has 8.10 meter in width and 6.6 meter in length. This *limas* is located next to the Kenduruan River and facing the street. Therefore, the front side of the house is transformed into a small shop for selling food and snack. The shop has different roof structure and use masonry for wall structure. The layout of *limas* is not changed, except the *bengkilas area*. Because of the small shop function, the *bengkilas area* is used for kitchen and food processing area at one side and living room at the other side. The public and services zone has no clear border at this area. Because of the small shop, the *bengkilas area* has limited natural lighting. The rooms with openings are only at bedroom and family room. The artificial lightings are found at *bengkilas area* for day and night usage, and bedroom for night usage.

### 6.2. User behavior on thermal and visual comfort

Physically, traditional buildings have a passive design for low energy use [20]. Traditional buildings are designed to receive a lot of solar energy with little use. Therefore, the principle of zero energy building design has been applied to traditional buildings [21]. In current context, the climate is not same as in the time when the *limas* house was built. Therefore, the user might change their behavior and activity to fulfil their comfort. As *limas* was built when there was no electricity, the rooms depended on natural lighting from windows. In current context, when the electricity is available, the artificial lights are used in each room and use at night. The lights are also use for daily activity only if the natural lighting is insufficient for detailed work.

The current activities in *limas* influence the resident to make some changes on their house. The *limas* of Muhammad is also used for selling clothing products. The cloths and the show case were positioned at public area (*bengkilas tengah*). For visual comfort, the artificial lights were placed at the ceiling. The lights were used at day and night. For day use, the lights were on along with the natural lighting from window. Similar to this, the *limas* of Kikin also use the front area of the house for selling the snacks and drinks. The transparent *pagar tenggalong* were replaced by a masonry wall. Therefore, the natural lighting was blocked by the wall. The artificial lights were placed at the *bengkilas tengah* that was used for kitchen and public area. The lights were use at day and night. On the other hand, the resident of *limas* of Wak Da had different behaviour. The user drastically removed the wall of *bengkilas bawah* (terrace). The windows were opened at day for natural lighting. The artificial lightings are placed at all rooms and only used at night. The natural lighting is sufficient for resident's activities.

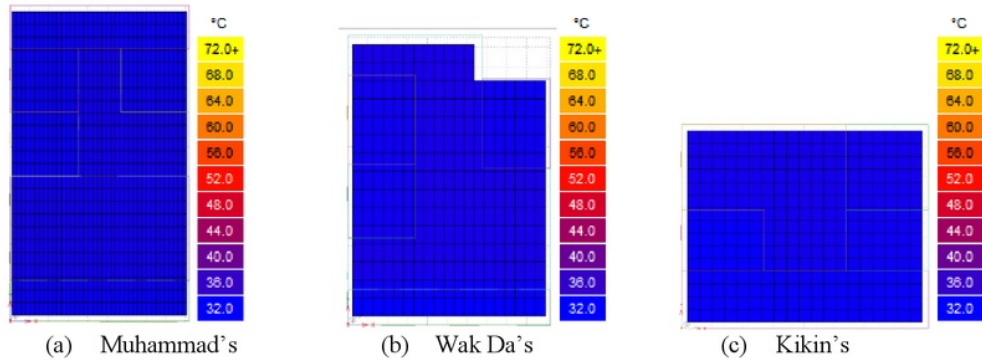
For thermal comfort, the *limas* of Muhammad and Kikin have electric fans inside the bedroom and the living room. The average usage of fan was in the noon and afternoon. The field measurement had done in October 2017. The measurement was conducted in the morning from 09.00 am to 01.00 pm, and evening at 03.00 pm to 06.00 pm. All of the residents turn on the light after 05.30 pm for night use. The average range of temperature was 26°C to 27°C at 09.00 am and increased to 29°C to 30°C at 01.00 pm. The illumination value was range from 60 to 80 lux. In the evening, the average range of temperature reached 29°C to 30°C at 03.00 pm and decreased to 28°C at 05.00 pm. Table 1 shows the result of temperature and illumination measurement of the three *Limas*.

**Table 1.** Temperature and illumination measurement of the observed *limas*.

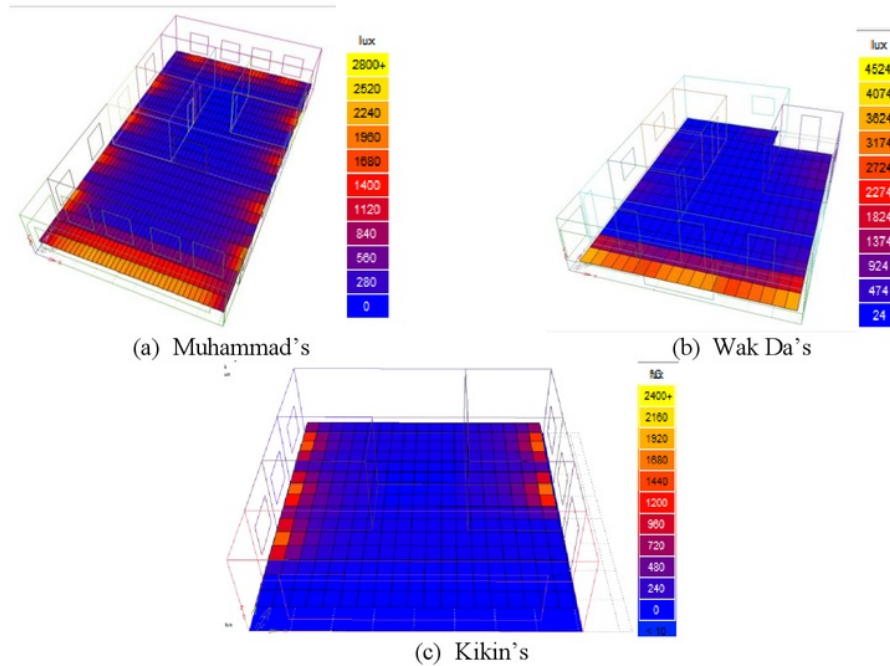
	09.00 am – 01.00pm		03.00pm – 06.00pm	
	Temperature	Illumination	Temperature	The lowest Illumination
Muhammad	27° to 29 °C	60 lux at living room 68 lux at bedroom	28° to 29°C	48 lux at 05.30 pm
Wak Da	26° to 30 °C	80 lux at living room 68 lux at bedroom	28° to 30°C	50 lux at 05.30 pm
Kikin	27° to 29 °C	60 lux at living room 68 lux at bedroom	28° to 29°C	45 lux at 05.30 pm

### 6.3. Thermal and visual performance

The explanation of *limas* performance in the current context consists of two parts: thermal and visual performance. The first performance is aimed at knowing the thermal comforts in the *limas* house based on the room temperature. The second one intends to know the visual comfort in each space at *limas* house based on daylight level. The daylight level indicates the degree of illumination of incoming natural light. The analysis was done by using ecotect software v.5 with daylight factor of 10.000 lux for Indonesia [22] with brightness of openings 0.9. The result of the calculation is indicated by two pole of colors, extend from yellow to blue. The yellow pole means a high amount of illumination and temperature. The blue pole represents a small amount of light and temperature. Figure 6 and 7 show the performance of thermal and visual comfort of the three *limas* house. For visual comfort, the result was compared to the standard of illumination for visual work to examine the performance [22].



**Figure 6.** Thermal Comfort Performance



**Figure 7.** Visual Comfort Performance

**Table 2.** Illumination standard for visual work

Visual Work	Illuminance (lux)
Regular vision	100
Rough work with big details	200
Ordinary work, medium details	400
Heavy work with small details like drawing or sewing with a machine	600
Heavy work with small details, longer time like sewing by hand	900
Heavy duty work, very small details such as jewelry craftsmen	1300-2000
Extreme heavy work, very small details like fixing a watch	2000-3000

Source: Satwiko, 2008



Figure 9 shows the thermal comfort in the three observed *Limas*. The calculation was set at 12 noon, October 21<sup>st</sup>, 2017. The result shows the indoor temperatures on the objects are relatively same, indicated by the color of blue. The indoor temperature of the three houses is in the average 32°C. There is no significant difference in thermal comfort of all objects. Figure 10 shows different explanation of visual comfort performance among three houses. The first object is Muhammad's house. The visual comfort is range from 280 to 2240 lux. The area with highest illumination is the *bengkilas bawah* (terrace). The lowest range of illumination is 280 lux, located at *bengkilas tengah* (living room), *bengkilas atas* and *gegajah* (main room). The backside of the house receives more natural light since many windows located there. The *pangkeng* (bedrooms) get high light intensity at area under the window (280 to 1440 lux). The second *limas* is Wak Da's House. The visual comfort is range from 24 to 4074 lux. The area with highest value of illumination is the *bengkilas bawah* (terrace), ranged from 3174 to 4074 lux. The lowest one is same as Muhammad's house. However, the *pangkengs* (bedrooms) of Wak Da's has lower range of illumination value, 24 to 924 lux. The area under the window has purple color, indicated low natural light. The last *limas* was Kikin's. The visual comfort is ranged from 0 to 1440 lux. Its *bengkilas bawah* has lowest value of illumination. The *pangkengs* have 240 to 1440 lux of illumination with highest value at area under the windows. By comparing on the standard of illumination in Table 2, the small and detailed work can be done under the windows and terrace for all *limas* houses.

## 7. Conclusion

The three *limas* houses are still used as residence. In general, the formation of *limas* house does not change drastically. Building form of building, roof structure and spilt level are clearly showed. However, additional functions have been found. The change of user activities resulted in changes in spatial layout. It is the response on the residents' business activity and the increasing number of family member. Related to the building performance, the indoor temperature in *limas* is relatively the same as the average temperature in Palembang, ranged from 26° to 32° C. It implies that the indoor temperature in *limas* house is relatively hot for daily activities. In present time, with high density of buildings in the city, the existing openings of *limas* house is not enough to cool its inner space. Similar to this, the existing opening of the three *limas* accommodates lighting for ordinary activities with non-detailed work. The detailed work can be done near the openings that have better visual performance than other areas. Therefore, the residents tend to achieve better performance by adding electrical fan or air conditioner as well as artificial lighting. The paper suggests to not changing the openings of *limas* since it will reduce the authenticity of architectural value. However, the action will bring consequences on incremental of electrical cost. Further study on to what extent the electrical devices used in *limas* for fulfilling the user demand should be conducted in the future.

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