Bioclimatic Adaptation of Typical Houses in Kampong's Surabaya

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Abstract. Architecture of an ancient house in Kampong's Surabaya is one of the folk architecture creations in urban areas that grow and follow dynamics of urban development. In some of the city areas, this architecture is still sustainable for living space of city residents, especially for lower and middle class. Kampong as city villages has a high adaptability to development within the city so that it can adjust to future conditions efficiently. Cultures living in kampong require an appropriate strategy in associating with various limitations. However, limitation does not make a typical house in kampong uncomfortable and unlivable. Bioclimatic adaptation can be one of the strategies in development of typical ancient houses in kampong. It seems that typical ancient house in Surabaya City is influenced by tradition and style of Javanese, Colonial and Modern Architecture. Bioclimatic strategy is a design approach that considers the relationship of architecture to climate, biology, technology, in order to obtain comfort and energy efficiency. The form and performance of ancient house architecture in Surabaya City with a bioclimatic approach with occupant spatial interaction is an interesting topic for this study. This study uses quantitative and qualitative research which is descriptive research using field study and description method to explain the interaction between building and its occupant that creates architecture of residential houses and its transformation. Bioclimatic adaptation as a design strategy allows a unique form architecture, climate responsive and environmentally friendly. Facade engineering and building envelopes, eco-friendly building materials, vegetation and water elements, saving energy with smart technologies.

1. Introduction

Kampong as a city village is a residential area that concentration of most of urban population in Indonesia with its dynamics social, economic and environmental. Characteristics of kampong include density of buildings and high population with an incremental pattern of environmental growth. Kampong has a high ability to adapt to city development so that it can adjust to future conditions efficiently [1]. Residents of kampong generally have a certain culture which is a rural-urban cultural transformation. Cultures living in kampong can also be due to demands of an appropriate strategy in associating with various limitations. However, this limitation does not necessarily make houses living

in kampong uncomfortable and unlivable. Limitations can also give birth to typical houses in Kampong's Surabaya.

Folk architecture which gave birth to a typical ancient house is formed from a transformation process that is gradually long and repetitive in accordance with local behavior, habits and culture. An ancient house is a house that is more than 50 years old and has remained sustainable until now. This is related to high adaptability of kampong residents to all forms and structures of living space [2]. High adaptability is a potential to create a non-platonic form of residence. Relationship between residents and their houses is a relationship of interdependency transactional, which is humans influence to house and vice versa is house influences to occupants [3].

Climate can be a very important aspect that influencing a former of folk architecture as part of Vernacular Architecture [4]. Adaptation patterns can be understood more comprehensively by using a bioclimatic approach that emphasizes to importance of residential comfort, energy efficiency and its contribution to a livable city. Bioclimatic strategy will a designer direct to get interactive architectural design solutions to climate, biology and technology [5].

Bioclimatic adaptation can be one of the references to appreciation of folk architecture form of ancient houses in Kampong's Surabaya. How do bioclimatic adaptation patterns affect to transformation of ancient house architecture form and behavior of its occupant to be sustainable. Also how architecture of ancient houses in kampong's Surabaya contributed to city area development was focused in this study.

2. Materials and Methods

2.1. State of The Art

Adaptation is a process that includes several main efforts in adjust, reuse or upgrade an object (architectural) to make it more suitable for new conditions or needs, which is generally a direction as a number form of change. Adaptation in context of architecture can be divided into building adaptation and behavioral adaptation. Building adaptation takes the form of three principles, namely: change of function, change in size and change in performance [6]. There are three concepts of building adaptation [7], namely: generality, flexibility, elasticity. While behavioral adaptation [3], namely: adaptation by reaction, adaptation by adjustment, adaptation by with a drawl.

Folk architecture as part of vernacular architecture is an architecture that is closely related or contextual with local environment and resources that are processed and built with traditional technology [8]. This kind of architecture is an architecture that adapts local climate, uses local techniques and materials, that influenced by social, cultural and economic aspects of local community. Folk architecture one of them gave birth to typical ancient houses that are more than 50 years old and have remained sustainable until now. A typical ancient house in Surabaya city is influenced by tradition and style of Javanese, Colonial and Modern Architecture.

Kampong as city villages is a form of settlement in urban areas that are typical of Indonesia with the roots of a typical Indonesian settlement culture as well. Kampong has characteristics, among others: population still carries nature and behavior of rural life that is intertwined in close family ties, physical condition of buildings and environment is not a good and irregular, density of buildings and high population, basic services less.

Building performance in bioclimatic context is determined by ability of building to provide comfort to residents and ensure efficient use of energy. The biggest challenge in realizing an environmental comfort is thermal comfort, followed by visual and psychological comfort. Meaning of thermal comfort based on a psychological approach is most complete [9]. Meanwhile energy efficiency can be carried out in a cost of living cycle. This principle involves calculating building capital costs and building operational costs during of building life. Bioclimatic strategy is not focused on active systems but rather on passive systems through formations and building orientations that allow optimal design to reduce energy use.

2.2. Method

This study is a combination of quantitative and qualitative research (mix method) which is descriptive research using field study and description method to explain an interaction between building and its occupant that creates architecture of residential houses and its transformation. This descriptive study deal with fact gathering, identifying and interpreting about relationships between variables.

Variables that are observed are: bioclimatic adaptation patterns, architectural configurations, occupant spatial interactions, comfort sensations and energy performance. Data collection instruments used questionnaires, thermo-hygrometers and nomograms related to thermal sensation and energy performance. Populations and samples of object study are ancient houses in Kampong Peneleh, Kelurahan Peneleh, Kecamatan Genteng Kali, City of Surabaya. Kampong Peneleh is the oldest kampong of Surabaya City with many historical memories, unique architecture and environment and is a crowded and busy village since time immemorial, because of its strategic location.

The paradigm used to discuss about interaction of architecture, environment and its inhabitants in this case is a sustainable aesthetic paradigm. Paradigm of sustainable aesthetics relates to an ongoing understanding of architectural aesthetic philosophy [10], which there is a phenomenon of continuity and change.

3. Results and Discussion

3.1. Adaptation Pattern

Bioclimatic adaptation patterns form typical of ancient houses in kampong that are influenced by traditions and styles of Javanese, Colonial and Modern Architecture. In Kampong Peneleh Surabaya City, percentage of ancient houses existence consisted of 35% Javanese House style, 18% Colonial House style and 47% Modern House style.

Figure 1. Typical of ancient house architecture in Kampong Peneleh Surabaya City

All types of ancient houses have terraces as wide as the front side of building, which most extensive is a terrace in Colonial House while narrowest is in Modern House. Front room in house

(from entrance) functions as a Living Room. Behind Living Room is Bedroom. In Colonial House, placement of Bedroom can be on the left and right side, in Javanese House and Modern House are mostly on one side only (usually right side), while another side is used as a Multipurpose Room. Multipurpose Room in this case can be used for Family Room, Dining Room, Temporary Sleeping Room and others. Semi-open Bathrooms/Toilets and Kitchens are placed in back of the house. In Colonial House, existence of Bathroom/Toilets, Kitchen and partly in kind of Maid Room which is sometimes separated from the main house. Typology of ancient house plan in kampong looks similar between one house and another.

Thermal conditions of various typical ancient houses in Kampong Peneleh Surabaya City are shown in following graphic below.

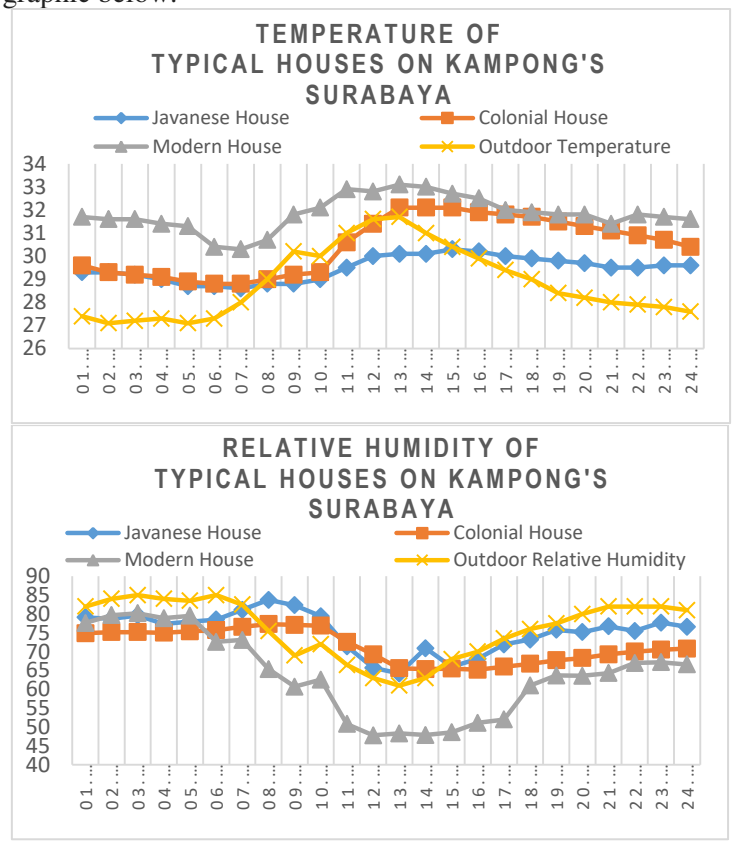

Figure 2. Thermal condition of typical ancient houses in Kampong Peneleh Surabaya City

The architecture of Javanese Houses and Colonial Houses shows that thermal conditions are relatively better than Modern Houses, which is average temperature inside of Javanese House (T = 29.5°C) and Colonial House (T = 30.5°C) is lower than Modern Houses (T = 31.8°C). Although the relative humidity average remained high in Javanese House (RH = 75.3%) and Colonial House (RH = 71.4%) but it could create a more stable thermal condition than in Modern House (RH = 63.8%). Appearance of Javanese House looks to be simpler but thermally of Javanese House shows best performance. Used of materials with high porosity such as wood and clay tiles with a small transmittance U-value, allows optimal evaporation. Configuration of wide openings like bovenlicht and windows that reaches 9-12% of facade area, also presence of a wide corridor in front of building makes indoor house cooler. This Javanese House plan is also not a lot of massive wall partitions in it (open floor plan) so that air circulation is smoother. Whereas Colonial Houses which tend to be more massive with large U-value material should be offsetted with better ventilation like wide windows and openings (ideally 20-40% of facade area) as right configuration, but in reality only 10-15% of facade area. Lately a lot of ventilations and windows are permanently closed which prevents air circulation within the room. The addition of massive wall partition in interior building causes high humidity

within the room, especially if ventilations and windows are always closed, humidity will be difficult to reduce because air circulation is stagnant. Meanwhile in Modern Houses it seems more concerned with appearance only than consideration of climate and environmental influences, so that thermal performance is the worst.

Based on thermo-hygrometer data logger recording on Multipurpose Room can be seen as a tendency of thermal performance in extreme conditions (table 1) of typical ancient houses in Kampong Peneleh Surabaya City as seen on following bioclimatic chart below.

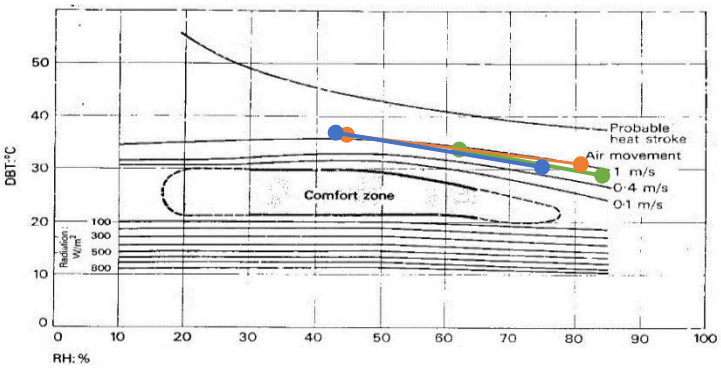

Figure 3. Thermal performance of typical ancient houses in Kampong Peneleh Surabaya City

Table 1. Thermal condition of typical houses Bioclimatic chart

Performance	Early day		Afternoon	
	°T	%RH	°T	%RH
Javanese House	27,4	84,3	32,5	63,2
Colonial House	28,8	75,7	35,6	43,6
Modern House	29,0	80,5	34,9	44,8

Comfort will be achieved if there is an air flow of 0.2-1.0 m/sec, while in all types of houses the air flow is only 0.1 m/sec.

The behavior of residents in responding to climate and environmental conditions is very significant in creating to environment comfortable and energy efficient. Active behavior is needed in realizing a thermal comfort but with passive building system technique. Behavioral adaptation of residents creates daily habits such as opening all windows in the morning around 6:00 a.m. and closing it again in the afternoon around 5:00 p.m. The habit of turning on fan during the day around 1:00-3:00 p.m. and reviving fan at the night around 6:00-9:00 p.m. Napping habits are usually carried out around 1:00 a.m. to 3:00 p.m. when an ambient temperature reaches hottest peak conditions.

Changes in a physical form of house buildings are not more than 30% while changes in environment are only around 10% in an effort of tidying up environment and make greening by planting flowers in pots, but not too significant. Social, economic and cultural conditions still remain relatively stable and even tend to stagnate because of many old residents over the age of 50 that stayed there.

3.2. Termal and Energy Performance

The most use of electrical energy in residential houses is for cooling load of room, which reaches 38-40% of overall electrical energy [11]. Cooling load is greatly influenced by solar heat infiltration in addition to heat gain coming from inside building itself. Amount of heat infiltration into building can be traced from overall thermal transfer value (OTTV) of the building envelope. In ancient house buildings in kampong with high density, facade configuration is a building envelope that most significantly influences to a difference of OTTV in building typically. While the roof is a building envelope which has an almost same effect because area and type of roof cover are same as using clay tiles.

Calculation results show that Javanese House with a wide overhang compared to low building height, making facade much overshadowed from exposure to solar heat so that overall thermal transfer value (OTTV) can be reduced. OTTV Javanese House 56-60 W/m2, Colonial House 65-68 W/m2, Modern House 69-71 W/m2. Colonial House building height which is supported by a large attic volume but without a roof ventilation is a lot of heat insulation, which reduces heat infiltration into the room. Building direction relative to sunlight exposure also plays a role in reducing an amount of heat that strikes building. However totally OTTV size is still higher than energy saving building which electricity consumption is only 45 W/m2. The passive system mechanism by optimizing natural

ventilation and lighting in ancient houses in kampong by using non electronic equipment for cooling the room, enabling efficiency of electrical energy. Buildings that are very climate and environmentally responsive can save electrical energy up to 60-70% and will save up to 30-40% more if it involves elements of vegetation and water [11]. Very limited of park or outdoor space in Kampong Peneleh Surabaya City causes a role of vegetation and water to be almost no effect. Based on the questionnaire can be known average of monthly electricity cost (basic electricity tariff 1467.28 IDR per kWh) on Javanese House 380,000 IDR equivalent with 259 kWh, in Colonial House 400,000 IDR equivalent with 273 kWh, in Modern House 440,000 IDR equivalent with 300 kWh.

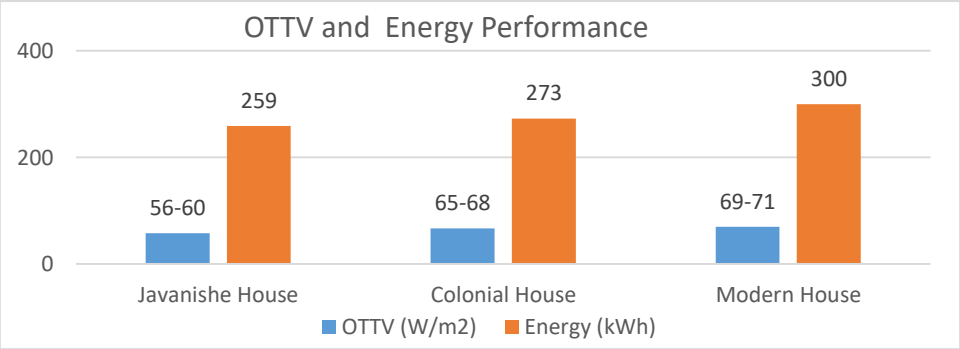

Figure 4. Profile of overall thermal transfer value and electricity load per month of typical ancient houses in Kampong Peneleh Surabaya City

3.3. Environmental Comfort

Environmental comfort includes physical, psychological and physiological comfort. Physical comfort is influenced by thermal conditions in building. Psychological comfort is related to safety, quiet environmental conditions and good social interaction. Physiological comfort is related to easing of accessing utility services for needs and wants of everyday life. Based on the questionnaire it can be concluded that environmental comfort in general is not too bad even though an occupancy satisfaction index is close to 50%.

Comfort sensation by residents of the house with daily clothes 0.34 clo, metabolism of moderate activity 70 met, ambient temperature 26.7-29.2°C with relative humidity 69.0-84.0% (board of meteorology and geophysic), wind speed in environment 0,1-0,27 m/sec, where a median rate of surface temperature of Javanese House (MRT = 29,5°C & RH = 75,3%), Colonial House (MRT = 30,5°C & RH = 71,4%), Modern House (MRT = 31.8°C & RH = 63.8%), where average PMV value based on the questionnaire ranges from +1.36 up to +1.56 that including the slightly warm category (table 2). Calculation of PPD as a function of PMV (using software) at hottest hour can be predicted percentage of dissatisfaction in Javanese House 43-55%, Colonial House 46-56%, Modern House 48-56%, which all of them exceeds than 10% for comfortable occupancy criteria. Thus most of the residents feel that their houses tend to be warmer thermally in a relatively long duration. Thermal comfort can naturally be felt around 4:00-8:00 a.m. in the morning.

Tabel 2. PMV index of typical houses

Scale of PMV index	
-3	Very cold
-2	Cool
-1	Slightly cool
0	Comfortable
+1	Slightly warm
+2	Hot
+3	Very hot

The PMV index of ancient houses is in the range of +1.36 up to +1.56 including the slightly warm category.

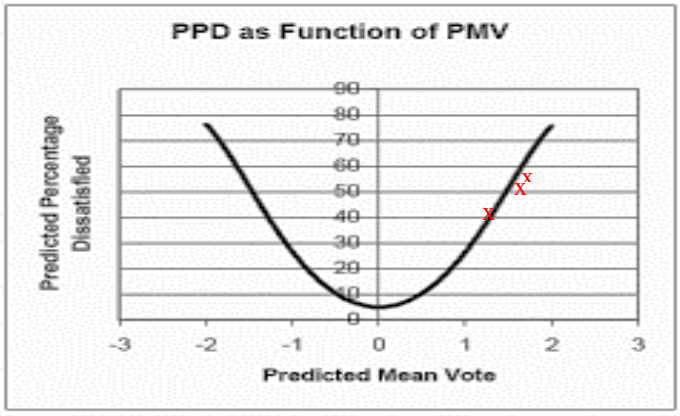

Figure 5. PPD as a PMV function shows a comfort level of the thermal environment

4. Conclusions

Bioclimatic adaptation of ancient houses in Kampong Peneleh Surabaya City forms typical Javanese House style, Colonial House style and Modern House style with different levels of bioclimatic performance. Bioclimatic adaptation allows transformation of buildings and behavior of residents to be more responsive to climate and environment. Typically, level of adaptation of Javanese Houses and Colonial Houses is better than Modern Houses. This is indicated by relatively good thermal conditions in ancient houses whose buildings are still original. However lately some physical changes in buildings and behavior of residents of ancient houses in Kampong Peneleh Surabaya City has led to a decrease in level of adaptation of his house. Use of new materials such as more solid walls and roofs with large U-value makes the room hotter and cooling load of the room also increases. Tendency to close windows and bovenlichts for a reason of reducing dust, pollution or safety actually causes air flow in to the room to stagnate so that temperature and humidity also increase. These unfavorable change results in decreased thermal and energy performance. The habit of opening windows and doors or turning on air conditioning equipment at certain times has begun to become disorganized because it is considered impractical. Actually, comfort of house environment can be pursued through active interaction between building houses and their occupants with a passive building system mechanism to save energy. A balanced transactional interdependency between building and occupants will affect to performance of both thermal comfort and energy efficient.

5. References

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