A Review on Malay Vernacular Architecture Ventilation Design Elements Effectiveness and Its Application Comparative Case Study: Rumah Kutai Tiang 12 (Vernacular) and Rumah Selangorku (Contemporary)

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Abstract. Thermal comfort and ventilation needs of occupants have been achieved successfully with the perfect solution by means of Malay vernacular architecture design. Ventilation have always been a major design element that needs to be thoroughly planned especially in Malay vernacular architecture in order to provide thermal comfort to the occupants. Amongst the various factors that affects ventilation in Malay vernacular architecture are the availability of multiple windows and openings, orientation of the building, roof design as well as variety of floors that contributes to further enhance the thermal comfort of the occupants. Thus, modern development needs to incorporate the suitable elements and applications for ventilation based on the design solutions provided by the Malay vernacular architecture into their designs. A study on vernacular ventilation assists in reinstating the relevance of its application in providing the most efficient thermal comfort to the occupants. The main focus of this research paper is to investigate the applications and significance of ventilation in Malay vernacular architecture as it could further assists designers in the future to provide modern developments that are more feasible in its design specifically on its thermal comfort. This research will provide adequate case studies and ethnographic observations to further enhance the understanding of Malay vernacular architecture ventilation elements whereby the researcher would act as a participant during the process. This research is aimed to change future architects and designers approach in planning and designing more feasible ventilated contemporary buildings.

INTRODUCTION

This paper aims to identify the interdependence relationship between the Malay vernacular architecture ventilation design elements and its application to the local climate's context. This identification process further strengthens the understanding of designers on how Malay carpenters were able to build and design vernacular architecture that accommodates and facilitates Malaysia's equatorial climate. According to Hutchinson, 'A region can often be clearly recognised by the character of its house. House design reflects critical factors such as climate, materials, economics and cultural background' [1]. Hence, reflection of occupant social background in the region, local materials usage, climatic factors consideration as well as thermal comfort requirements in a design of a house is the very definition of Malay vernacular architecture. This could be supported by a study done by Krisprantono in which he stated that the relationship between the practical knowledge and the theoretical notion that indulges the physical and non-physical traits of a specific place or location is being pursued in vernacular architecture [2]. Thus, material limitation,

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topography and climate variations are amongst the knowledge that is linked with the human versus nature in terms of environmental appropriate responses which are constantly being referred to as the physical character. While, social relationship, technology and traditions as well as history are referred to as the non-physical character. Furthermore, employment of multiple forms which symbolizes the relationship between mankind, society and the environment in which they live in as well the specific nature of the tradition are being emphasized as vernacular building expression by Krisprantono.

As time passes and technology have progressively advanced, the relevance of the Malay vernacular architecture ventilation design elements have been somewhat of a question mark throughout time. New technologies introduction as well as innovative interventions would likely cause the application for ventilation solutions based on vernacular design in modern contemporary building to lose its design identity and integrity as time passes.

Although various contemporary buildings have already utilized design solutions of ventilation elements based on Malay vernacular architecture, there are still many developments that are neglecting thermal comfort requirements and environmental based design during their planning and designing phase. This would indirectly contribute to the increasing regions' temperature and also towards global warming. Ventilation design elements are highly recommended to be designed by incorporating solutions provided by Malay vernacular architecture to fully maximize the thermal comfort to the building region.

Factors Affecting Malay Vernacular Architecture Ventilation

Malaysian Climate Context

High in humidity, copious rainfall and constant temperature are the local climate characteristics prior to being situated in the equatorial region. Winds generally have very low mass. Generation of a warmth and humid climate throughout the year due to its location being approximately near the sea and equatorial region [3].

The high temperatures and humidity characterization of Malaysia's climate classifies it as a warm and humid equatorial nation. Malaysia's air temperature averages out around the range of 22 to 32 degree Celsius with small diurnal and annual ranges [4].

The Malaysian Meteorological Department (MMD) had stated the increment of average air temperature in majority of cities in Malaysia. In almost two decades, 2 °C of average air temperature has increased from its minimum of 22 °C, also it had reached its highest temperature of 34 °C within that period. This clearly shows the changes experienced by Malaysian climate that starts from 1990 until 2010 [5].

In accordance to observation, research and reports, it indicates the increment of dampness level throughout the year followed by frequent masses of clouds appearances that covers water vapour content in the air. These naturally occurring climate changes assists in filtering direct solar radiation to Earth's surface. The decomposition process, algae growth and rusting are the effects of accelerating dampness in local climate. This climatic changes would likely cause damage to the structure and design of the local houses. Meanwhile, the winds in the local region typically have low speed velocities. These indirectly provides comfort to the regional people. High rainfall level recorded throughout the year averaging from 250 to 300 cm yearly [4]. During monsoon period, rain tend to be more extreme. The spreading of wind are more thorough due to surface height increment and lower on ground due to friction on that area. Velocity of the air flows are succumb to frictional effects that decelerates the air motion. Furthermore, monsoon season also poses serious hazards due to the presence of strong winds.

Thermal Comfort Requirements

The expression of satisfaction within the surrounding environment that is affected by convection, radiation, heat conduction and heat loss through evaporation in a state of mind in humans could be referred to as thermal comfort. Allowance for human metabolism to dissipate when heat is generated causes thermal comfort to maintain at a certain level that thus, maintains and regulate the surrounding thermal equilibrium [6].

The traditional Malay house has progressively evolved in terms of design as readily present local materials that are best opted for local climates and environmental conditions are fully utilized. The local inhabitants of this archipelago which are the Malays are understandably respectful towards their environmental conditions as well as the metaphysical elements of their surrounding context [7]. Thus, it is considered to be harmonious with nature when the locals uses natural materials on a daily basis. Amongst the essential features in relation to traditional Malay architectural practice are the qualities of the indoor environment, feasible site planning, materials and resources usage,

design and energy efficient during construction process. A perfect vernacular architecture that is environmentally feasible was a Malay house design.

Husrul Nizam made clear emphasised on the knowledge possessed by the local Malays in the past which made them seemed to understand bioclimatic approaches better than current contemporary designers [8]. While Nasir explained that in order to minimize the amount of heat transfer into the house, the use of low thermal capacity building materials and allowance of ventilation for cooling and reducing humidity are provided in the overall Malay house construction [9]. It is also design and built to regulate and control glare, direct solar heat and also provide protection against rainfall. In order to provide a more comfortable and cooler environment, natural vegetation and greeneries are provided in the surrounding context.

The materials used for thatch roof are mainly from 'rumbia' leaves which is a lightweight material suitable for roof construction as it acts as an insulator which reduces heat during the day and provides cooling air at night. In order to allow natural day lighting and ventilation emission into the house, the gable ends are constructed with carefully carved wood which serves as a screen for the process to take place.

In order to avoid flash flood and dampness, Malay houses are built on the ideal solution in which to raise the floor on the post above the ground [10]. This indirectly allows ventilation of the house through the cracks in the raised floor. Provision of efficient ventilation and thermal comfort are provided by the open spaces, roof and high ceiling of the Malay houses design, the creation of multilevel floor by the master builder which could be used as separated spaces allows the design flexibility of open spaces in Malay houses [7]. Multiple windows in Malay houses design provides efficient ventilation as well as pleasing scenery which indirectly creates comforting and relaxing surrounding environment. The materials being used also provides comforting and coolness to the inside spaces of the building [11]. Thermal comfort of the dwellers are achieved effectively as multiple windows and openings provides ventilation and air flow in the interior spaces that significantly cools the space. Temperature of Malay houses can be distinctively decrease by the usage of local materials such as 'rumbia' for thatch roof, 'mengkuang' weaving and bamboo roof and wood made of 'cengal'. Fig. 1 ilustrated the malay house site planning layout to describe malay vernacular architecture ventilation

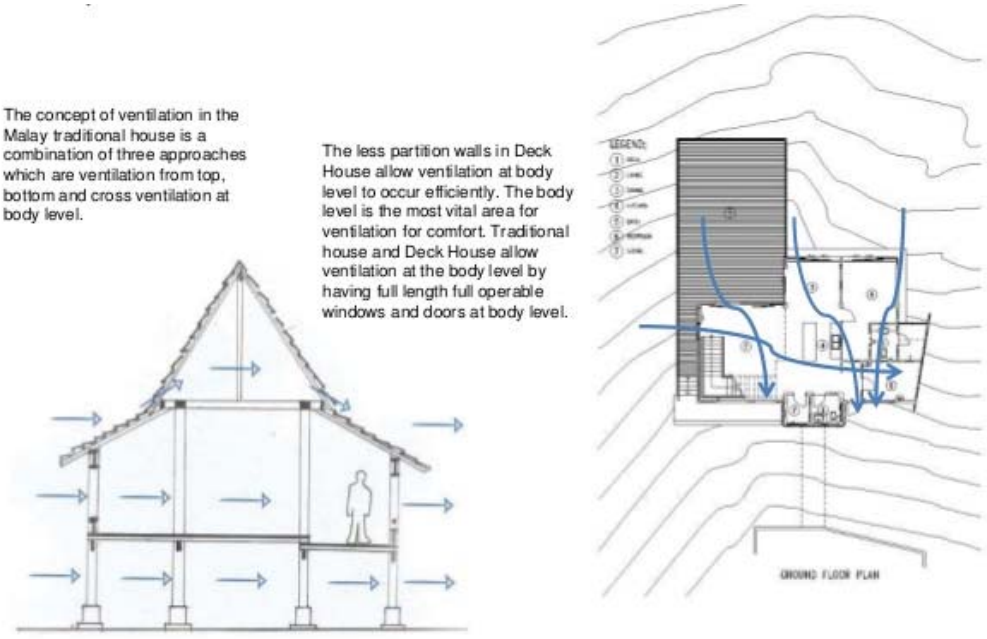

FIGURE 1. Illustration of Malay House Site Planning Layout [12].

PARAMETERS FOR DESIGN SIMULATION

The selected design simulation software for this research is the INSIGHT plugin from Revit Autodesk as it is deemed suitable and adequate in acquiring the objectives of the study, which is to formulate the settings to simulate relative humidity, rate of air flow and temperature of the air. As of the natural ventilation, the softwareof MacroFlo is

coordinated into the INSIGHT simulation, which is applied further to simulate the flow of air driven by pressure of the wind and buoyancy forces through components of doors, windows and openings. The MacroFlo application is also integrated within Apache, which could also be used to simulate relative humidity together with temperature of the indoor air based on the setup weather design database. The table below shows the materials of the buildings being assigned to both of the Rumah Selangorku and both Malay vernacular house in INSIGHT software. The proper materials for the building is vital to attain precise simulation readings. However, certain materials were not available for the design database setup such as regional materials which includes a gap timber floor, a bamboo thatched wall as well as an 'attap' roof usually made from palm leaves. Hence, the materials resembles the most to it were chosen for the simulation. Details of the simulations parameters are shown in Table 1.

TABLE 1. Simulation of materials and their U-Values

Elements of Construction	**Vernacular Malay House**	**U – Value (W/m2k)**	**Rumah Selangorku**	**U – Value (W/m2k)**
Roof	Sloping Roof – Domestic	3.3770	Flat Roof	0.2500
Ceiling	Timber – Joist Internal Ceiling	1.2580	100mm Reinforced – Concrete Ceiling	3.6840
External Wall	Timber Frame Wall	0.4490	Brick / Block Wall	0.4395
Internal Partition	Frame Partition With 1 In. Wood	1.1630	115mm Single – Leaf Brick	1.9710
Ground Floor	Un-Insulated Suspended Timber Floor	0.6280	Slab on grade Floor	0.1980
Door	Wooden Door	2.1945	Timber Flush – Panel Hollow – Core Door	2.3255

RESULTS AND DISCUSSION

The location and sizes of the openings are the major factors that allows air intake to flow in the building effectively. Table 2-5 detailing the simulations result of the analysis. As per the tabulated data, the Malay vernacular house is able to register higher percentage reading of openings compared to the Rumah Selangorku building.

TABLE 2: Areas of openings and its percentages of case study

Building's Name	**Simulation's Location**	**Total Ext. Wall Areas (M2)**	**Ext. Opening Areas (M2)**	**Percentage (%)**
The Rumah Kutai	Selangor / Subang	270.0	50	18.5
A Unit of Rumah Selangorku	Selangor / Subang	120.0	10	8.33

TABLE 3. Temperature of Indoor Air of case study

Thermal Variable	**Statistics**	**Case 1: Rumah Kutai Tiang 12**		**Case 2: Rumah Selangorku (1st Floor)**		**Case 3: Rumah Selangorku (11th Floor)**	
Air Temperature	Space	Rumah Ibu	Dapur	Liv/ Din	Kit	Liv/ Din	Kit
	Mean	25.1	25.2	26.8	25.4	26.8	25.4
	Max	30.6	29.7	29.0	28.6	29.5	29.0
	Min	22.7	23.5	24.2	23.7	24.1	23.6

TABLE 4. Approximate Humidity of case study

Thermal Variable	Statistics	Case 1: Rumah Kutai Tiang 12		Case 2: Rumah Selangorku (1st Floor)		Case 3: Rumah Selangorku (11th Floor)	
Relative Humidity (%)	Space	Rumah Ibu	Dapur	Liv/ Din	Kit	Liv/ Din	Kit
	Mean	80.4	79.5	74.5	78.4	75.0	78.6
	Max	99.8	95.6	92.7	93.6	92.7	93.5
	Min	56.4	58.9	54.0	59.7	53.5	58.2

TABLE 5. External and Internal Ventilation of case study

Thermal Variable	Statistics	Case 1: Rumah Kutai Tiang 12		Case 2: Rumah Selangorku (1st Floor)		Case 3: Rumah Selangorku (11th Floor)	
Macroflo Internal Vent. (l/s)	Space	Rumah Ibu	Dapur	Liv/ Din	Kit	Liv/ Din	Kit
	Mean	413.4	20.9	132.5	112.0	142.8	110.6
	Max	2308.8	234.4	323.6	293.3	413.4	344.2
	Min	0.0	0.0	13.9	0.4	15.5	0.0

Thermal Variable	Statistics	Case 1: Rumah Kutai Tiang 12		Case 2: Rumah Selangorku (1st Floor)		Case 3: Rumah Selangorku (11th Floor)	
Macroflo External Vent. (l/s)	Space	Rumah Ibu	Dapur	Liv/ Din	Kit	Liv/ Din	Kit
	Mean	1450.4	132.7	18.4	11.1	31.8	18.5
	Max	7904.6	781.5	189.8	145.6	335.5	256.7
	Min	3.2	0.0	0.0	0.0	0.0	0.0

The house forms were the main basis of selection for the case studies. The height of the stilt in Rumah Kutai prior to the location of the house was the core selection criteria for this study. Thus, the location and form provides the most significance typologies for this study. While, the social project developments could be design and constructed any part of the country. Thus, the social project of Rumah Selangorku is best served as the most suitable representative of social housing project in the country.

As obtain from the simulations as shown in Fig. 2 and Fig. 3, it can be clearly seen the temperature of air in the Malay vernacular house and the Rumah Selangorku unit has no major differences between them. The models were able to attain the levels of comfort prior to its efficient mean air temperature achieved. However, the levels of relative humidity indicates it is slightly high than our average climate. Although the level of humidity is relatively high, the changes in the temperature of the air is of a small percentage. As stated by Fisk (1981), the changes of temperature by 1°C is only caused when there is an alteration of 25% of relative humidity to 75%.

The most vital reading obtained while conducting this simulations are the movement of air flow. The process of evaporation through the heat loss process is further aided through the air movement in this scenario. The small generation of heat loss through the body is caused by low air movement. As suggested by Fisk (1981), increment in the temperature of air is caused when there is increased in air movement in about 150.0 l/s which also assist in the heat loss through the body process. In a nutshell, the Malay vernacular house provides more comfort and better provision of shelter as compared to the Rumah Selangorku as it has high movement of ventilated air.

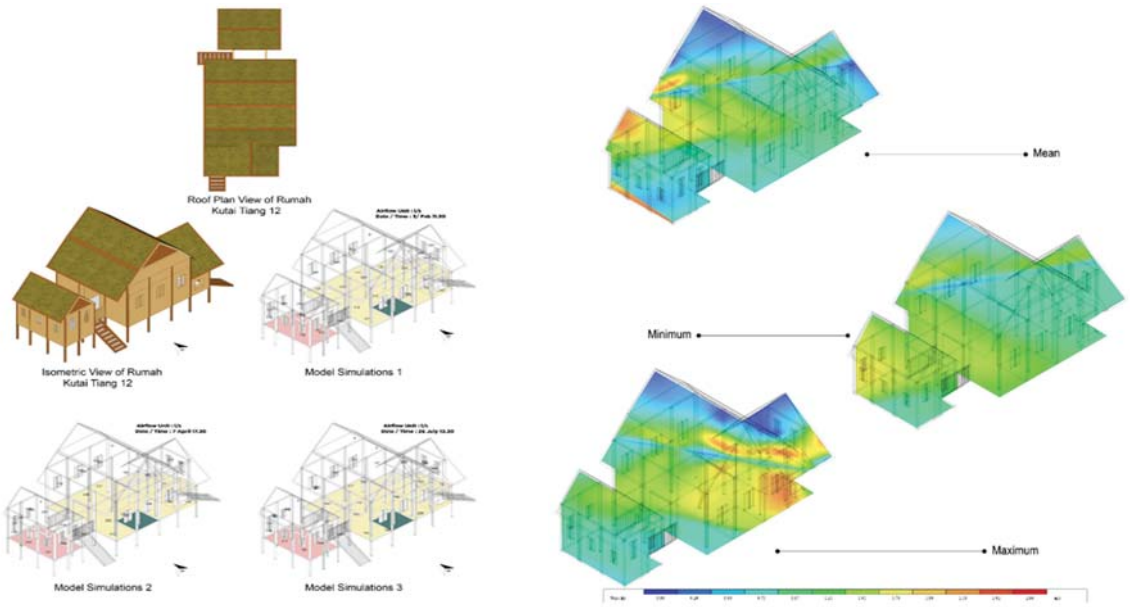

FIGURE 2. Heat and ventilation simulations of Rumah Kutai Tiang 12

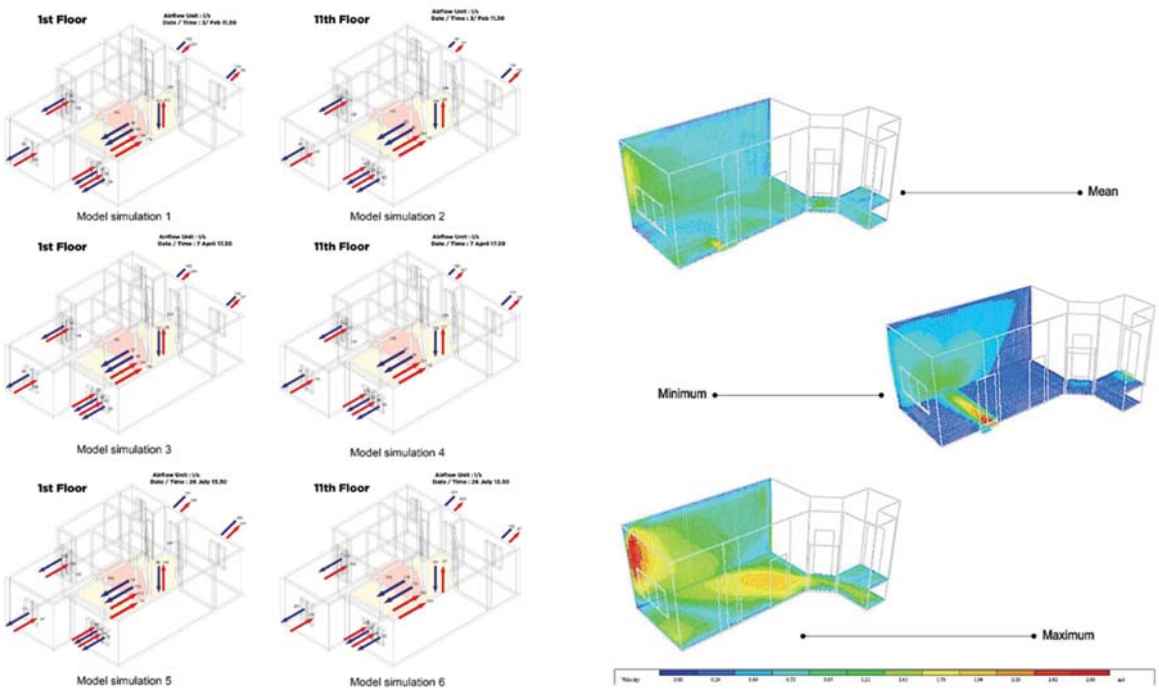

FIGURE 3. Heat and ventilation simulations of Rumah Selangorku 1st and 11th floor

CONCLUSION

In a nutshell, in the design of Malay vernacular and social projects developments there were several issues being discovered. As can be gathered from this study, the social projects uses materials such as bricks and concretes that have high capacity of thermal as compared to the Malay vernacular house which uses materials that readily gives out heat and helps cools the building . These materials used in the social projects can causes discomfort during night time as it has high heat capacity and usually stores a high amount of heat. In the social Rumah Selangorku project, the openings are situated on the higher part of the body and are usually small as compared to the Malay vernacular house which have openings of full length size at the body level.

Thus, the social developments are usually not successful in providing cross ventilation effect efficiently. The walls are shaded from glare, sun radiation as well as rainfall as they have overhangs structures that are vital in the opening components. However, this main design element is often not thought of in modern contemporary development. The Malay vernacular houses are usually face on the east to west direction or the direction of Mecca for religious purposes which in this study is coincidental as the external wall orientation is facing the sunlight direction. However, in this social developments, the orientation and direction of the building is not centred for profit centric. Plus, the serambi is designed in a front to back spatial layout followed by the rumah ibu and kitchen in Malay vernacular house which enhances the privacy levels of the family in that space as well as encourages interactions within the neighbouring context.

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