International Journal of Sustainable Construction Engineering & Technology (ISSN: 2180-3242)
Vol 5, Issue 2, 2014

Natural Ventilation Performance of Kedah Vernacular House

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Received 11 November 2014; Revised 7 December 2014; Accepted 22 December 2014

Abstract

As processed energy becoming more expensive, people have started to look for natural sources for option to provide their needs and comfort. Natural ventilation is one of the passive approaches that have recently become one of the important approaches in building design. However, architecturally, this approach is not considered new as a lot of previous buildings before industry era are totally depending on natural sources to ventilate their indoor spaces. Therefore this study was done to look into how these architectural details in Malay vernacular houses may affect the air movement performance around them. Two case studies of vernacular houses were chosen with design elements identified as natural ventilation attributes. Several points were identified inside and outside of the house where the wind speed of their surrounding were taken hourly in daytime for three days. The data were than compared to the building elements of the spaces. Both houses shows how building orientation and position of ventilation openings play the major role in determine the indoor air movement performance. However due to having other unintentionally openings such as gaps on roof design and gaps in flooring construction installation may also allow air flow to sip into the building despite of not having proper opening facing the cross ventilation. Besides that, by having openings at high level at the high roof may also encourage natural air flow via stack effect ventilation. Wide and full height window design may also become one of the most significant element to allow ventilation as proven in this research.

Keywords: *Natural ventilation, stack effect ventilation, cross ventilation*

1.0 Introduction

Designing a comfortable building is always a challenge in tropical area due to the hot and humid environment. Therefore, air cooling mechanical system becomes very common in tropical houses. The system relies on processed energy, which lately becoming more and more expensive. With the reality that Heating, Ventilating and Air Conditioning Systems (HVACs) itself consumes up to 68% of all energy usage nowadays, people have started to consider natural option to comfort their indoor surrounding [1].

Ironically, depending on natural sources in terms of providing natural ventilation is not new in architecture. Since years before, vernacular buildings have been relying on natural ventilation to provide indoor comfort successfully [2]. Hence, this study was done to look into the building elements impact on the natural ventilation objectively.

Natural ventilation may occur in two ways which are cross ventilation and stack effect ventilation. Both depend on air pressure difference to move from one point to another. Cross ventilation normally moves horizontally with the presence of wind [3]. Cross ventilation advantage may be exploited by having openings through in the path of the ventilation flow. Good design always integrates and oriented to the advantage to gain good indoor air movement [4]. Meanwhile, stack effect ventilation depends on thermal buoyancy to create the air movement and normally moves vertically along a stack throat. Depending on the pressure difference via air temperature difference between indoor and outdoor, the indoor air will move vertically either upward or downward to flow out to be replaced with fresher air [3].

This study was done by making data comparison on the performance of natural ventilation between two case studies of vernacular houses with different layout and design. Both are located nearby in a same compound and setting of surrounding. The two vernacular houses selected are Tok Su House and Sri Banai House in Alor Setar, Kedah.

2.0 Methodology

Identification of Case Study

Tok Su House and Sri Banai House are selected based on their vernacular design criteria which latter to be called the physical architecture elements. Located nearby and having about the same floor area and height minimizes the limits of the study. As other ordinary Malay vernacular house, both houses have an ample number of openings and without proper ceiling, thus allowing air circulation in the house horizontally and vertically. High openings on the roof second tier of both houses indicate potential on having stack effect ventilation [5]. Both houses are elevated on stilts with variety levels that mark the space boundaries and functions. Having the floors elevated also indicate potential of ventilation flow under the floor that may also sip into the houses through wood joint gaps.

Figure 1: Tok Su House

Figure 2: Sri Banai House

Physical Architecture Elements Study

The study was done to understand the physical elements of the house which latter on compared with the ventilation performance of that particular areas. The elements were structured into three main categories with sub-elements as in Table 1.

Table 1: Building Elements and Sub-Elements

Elements	Wall	Roof	Floor	Building Orientation
Sub-Elements	- Material - Ventilation Openings; windows, doors and other openings	- Roof Design - Roofing Materials	- Flooring Materials - Flooring Joints	- Sun Path - Wind Direction

Ventilation Measurement

Various points were indicated inside the houses while twelve points were indicated outside surrounding the two house at minimum 2.1 metres from the building wall. The indoor points were indicated to cover all main spaces inside the building. Anemometers were used to collect air movement data at these points. Air movement was recorded via wind speed in meter/second, air temperature in degree of Celcius and air relative humidity in humidity percentage. Air temperature and air relative humidity data was used in the study as a comparison data to see any correlation of the air movement with the house physical architecture . The data was taken hourly from 8.00am to 6.00pm in three days to get the average data of the days. A range of 10 minutes is set to be the maximum gap of time for the data collection at all the points within the same hour.

The indicated points inside the house were marked 1 to 15 in Tok Su House and 1 to 20 in Seri Banai House as shown in the Figure 3 and 5.

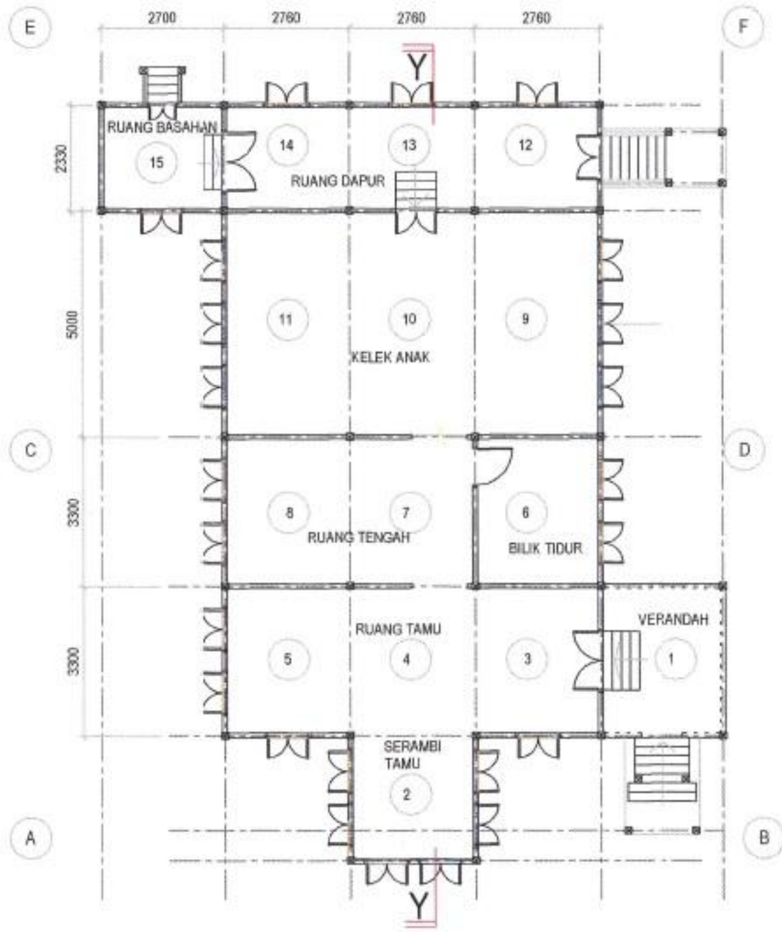

Figure 3: Floor Plan of Tok Su House

Figure 4: Cross Section of Tok Su House

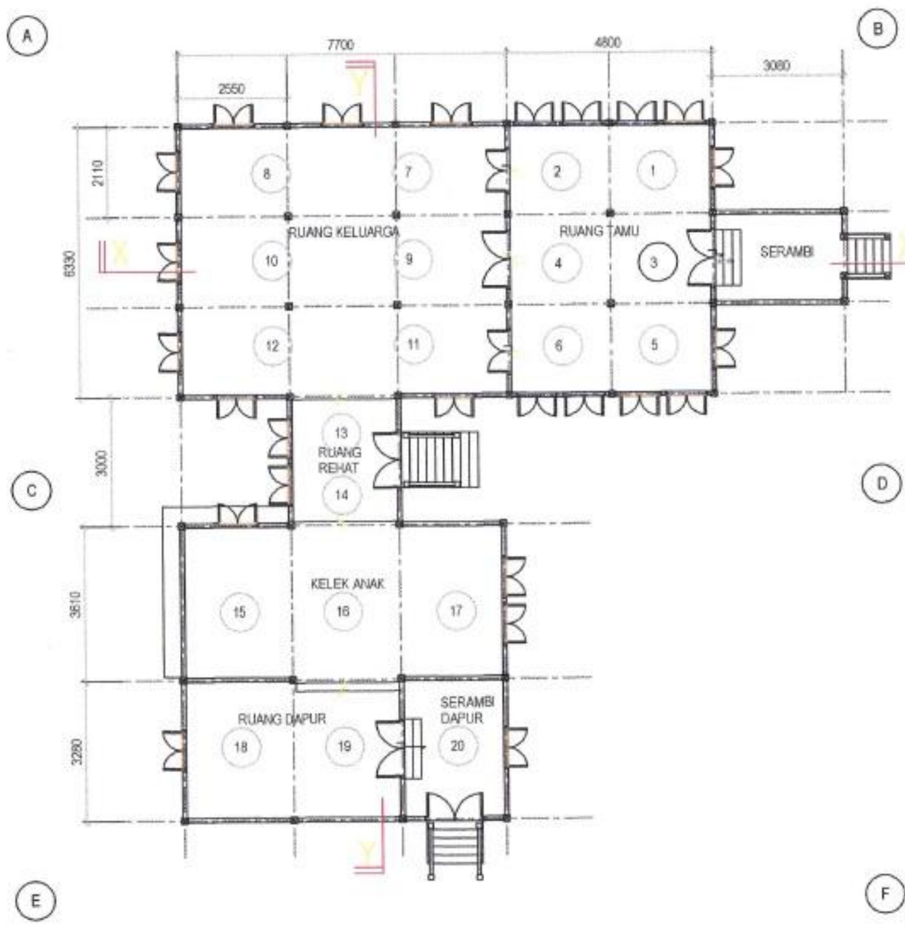

Figure 5: Floor Plan of Seri Banai House

Figure 6: Cross Section of Sri Banai House

3.0 Results and Discussions

Tok Su House (Physical Architecture Elements):

Tok Su House is an original vernacular house located at Kampung Warisan, Alor Setar, Kedah. The entrance of the Serambi and the Anjung Tamu is facing the South. Therefore, the elongated walls of the house are facing East and West.

The building envelope is totally made of wood. Carved wood panels are used for the bottom part of the walls whereas vertically organized wood planks are used for the rest. All spaces are provided with windows. The windows are directly sitting at floor level with wooden kerbs that act as the window leaves stopper. Most of the windows are about 0.9 meters width and 1.8 meters height. Ventilation openings are used in most of the spaces, placed above windows and at upper walls.

The roof structure is rather a simple gabled roof with ventilation openings. It consists of a main roof structure for the main building with small attached gabled roof for all attached spaces. The roof is covered by ardec roofing and layered dried leaves roofing to cool the house.

The house's floor level is raised at about 1 metre at the Serambi and about 1.95 meters at other spaces. Floors are made of wood with gaps between the flooring wood planks that allow ventilation from under the floors.

Sri Banai House (Physical Architecture Elements):

Sri Banai House is also an original vernacular house. It was originated from Kubang Pasu and was twice moved before relocated at Kampung Warisan, Alor Setar, Kedah. The entrance Serambi is facing the West. As the house foot print is L-shaped, most of the walls are also facing West and East.

The building envelope is totally made of wood which consists of layered horizontally organized wood planks as the wall panels. 1 meter width windows with two leave panels are provided in all spaces except for *Kelek Anak* area. The windows are also directly sitting at floor level with wooden kerbs that act as the window leaves stopper. Ventilation openings are used in most of the spaces, placed above windows and at upper walls. In Kelek Anak area, a simple structure of shelf is erected on one side of window-less area. Gaps in the joint may also become as wind flow source.

The roof structure is a double tiered roof with different angles. The upper roof is designed higher to provide high spaces inside the building especially for the *Ruang Keluarga*. The roof is also covered by ardec roofing and layered dried leaves roofing to provide heat insulation for the house.

Same as Tok Su House, Sri Banai House's floor level is also raised at about 1 metre at the Serambi and about 1.65 meters at other spaces. Floors are made of wood with gaps between the flooring wood planks that allow ventilation from under the floors.

Tok Su House (Air Movement Analysis)

The data of air movement for Tok Su House was identified and shown in Figure 7. These are the average data of three days. 15 points of indoor air movement are compared to the average data of outdoor air movement. Based on the data collection, the highest indoor wind speed level recorded was 0.6m/s at Point 2 (*Serambi Tamu*) and Point 5 (*Ruang Tamu*) at 5.00pm and at Point 9 at 3.00pm. Having a lot of windows may allow rapid cross ventilation in the areas.

It is interesting to see that at certain hours, the indoor air movement at certain point records higher air movement compared to the average outdoor air movement. As early at 8.00am, while the outdoor average air movement are less than 0.1m/s, Point 1, 2 and 7 record 0.1m/s air movement. While at 9.00am, the same points record 0.2m/s air movement when the outdoor air movement records 0.1m/s. These are the areas of the *Verandah*, *Serambi Tamu* and *Ruang Tengah*. The Verandah is actually an area with walls, however by using ornamental carved hollow panels for the walls may allow high air movement inside the area. Meanwhile, despite being at the centre of the house, *Ruang Tengah* is linked with two doors that attached to *Serambi Tamu* and *Kelek Anak* which are highly ventilated. Without any ceiling, the roof gaps between the roof rafters and the roof panelling may also become the ventilation openings for the area as shown in Figure 10.

At 16.00pm, Point 9 which is the *Kelek Anak* area records 0.6m/s air movement compared to 0.5m/s of outdoor air movement. The highest difference was recorded at 13.00pm at Point 15 where the indoor air movement was 0.3m/s while the outdoor air movement was only 0.1m/s.

Besides that, the overall graph pattern of indoor air movement at all points resembles the same pattern with outdoor air movement. A lot of windows openings in most areas may be the factor of this scenario. The most unaffected points by outdoor air movement were recorded at Point 7 (centre of *Ruang Tengah*) and 13 (centre of *Ruang Dapur*), at 17.00pm. Both points record 0.2m/s of air movement while the outdoor air movement was recorded 0.85m/s. However, 0.2m/s air movement is still considered good for indoor areas.

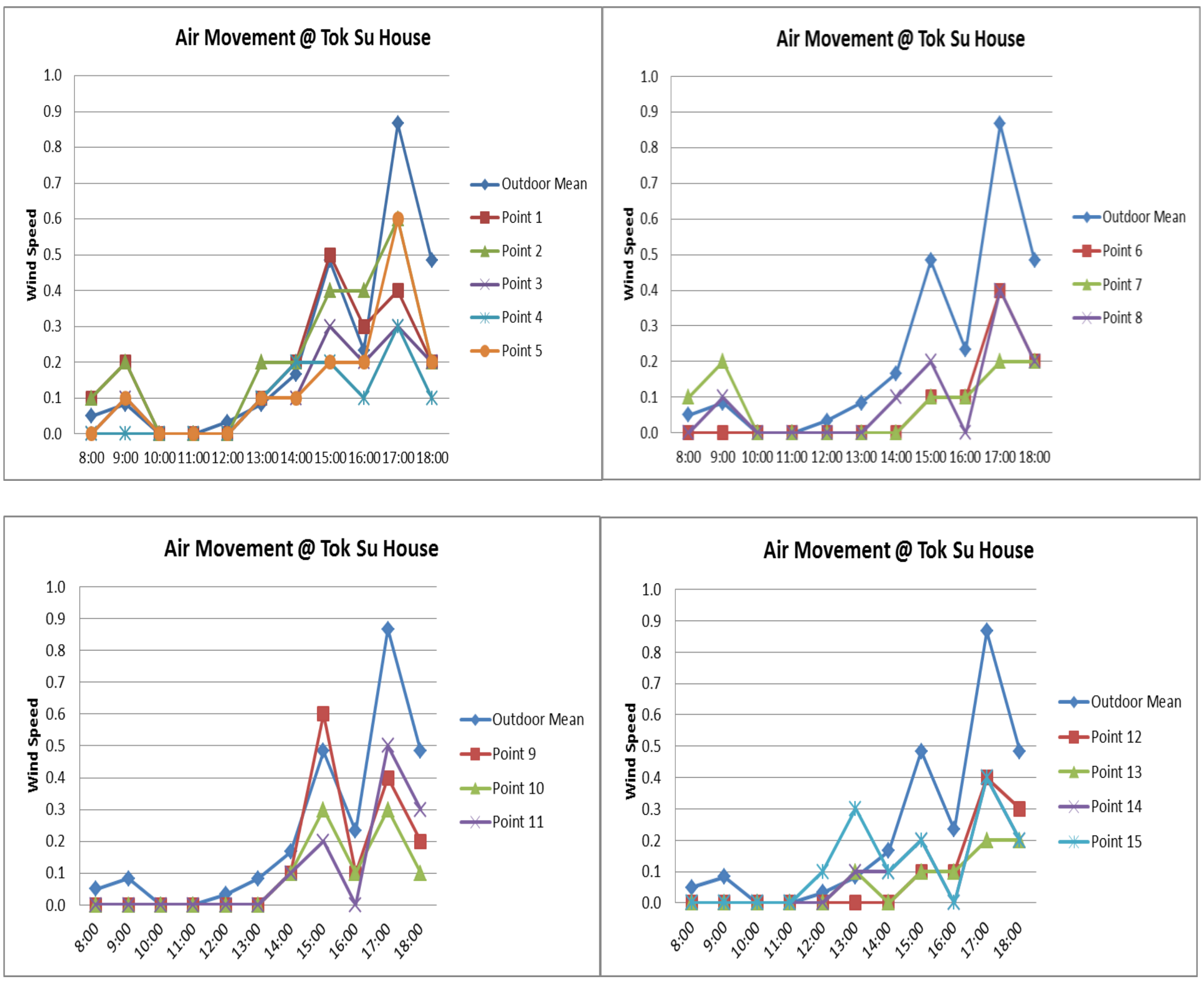

Figure 7: Graph of Wind Speed against Time for Tok Su House

Figure 8: Verandah of Tok Su House with ornamental ventilation holes

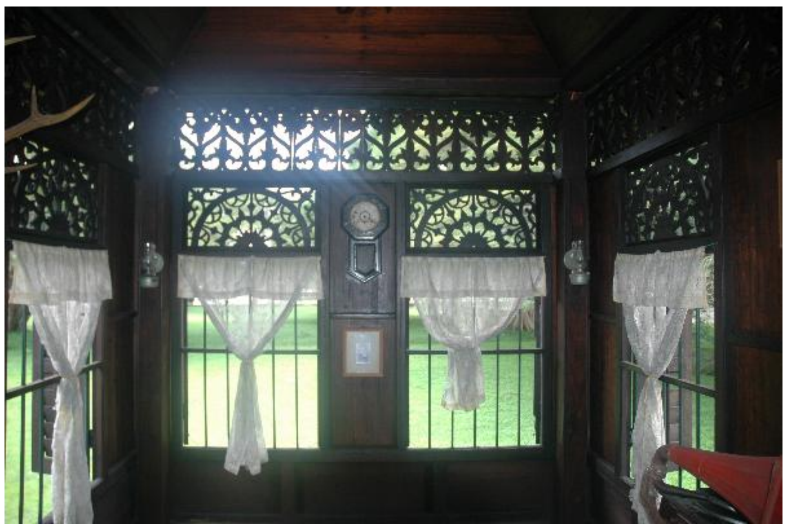

Figure 9: Fully ventilated Serambi Tamu of Tok Su House

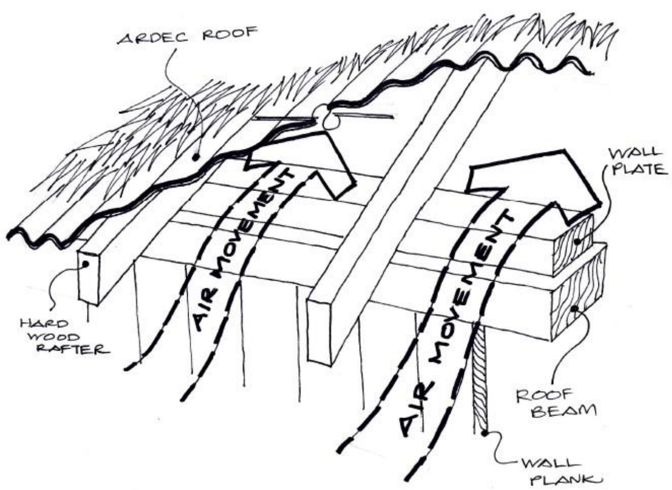

Figure 10: Gaps between rafters and roofing that may allow air movement

Seri Banai House (Air Movement Analysis)

Meanwhile, data of air movement for Seri Banai House was identified and shown in Figure 12. Average of three days data of 20 points inside the house were gathered and plotted on graphs and compared with the average outdoor air movement data. As shown in the graphs, the highest indoor wind speed level recorded was 1.3m/s at Point 11 at 17.00pm. The outdoor air movement at the same hour was recorded 1.2m/s. This is the only scenario in Seri Banai House that records higher indoor air movement than the outdoor where there is possibility that stack effect ventilation happens.

The overall graph pattern of indoor air movement at all points also resembles the same pattern with outdoor air movement. *Ruang Tamu* indoor air movement at Point 1 to 6 in the afternoon were recorded slightly low compared to other spaces air movement. The same result also happened at *Kelek Anak* and *Serambi Dapur* at Point 15 and 20. This may be due to the direction of cross ventilation on site. However, the air movement in the areas are still considered good.

Besides having an ample number of windows to flow the ventilation in, there are several other openings that also contribute to the indoor air movement. Most of the wall panels are equipped with upper ventilation openings via ornamentation on top of the walls as shown in Figure 11. The double tier roofing with different angle also provides gaps at the roof rafter joints to allow ventilation flow as shown in Figure 13 and 14. The higher the roofing structure the better performance of stack effect may be happened in that particular area. This may be one of the factors that contribute to a good air movement performance in *Ruang Tamu*.

At *Kelek Anak* area, inspite of not having any window on one side, the wall are design with shelves with ventilation openings to allow air movement into the area. This is shown in Figure 15.

Figure 11: Ample size of window and ventilation openings.

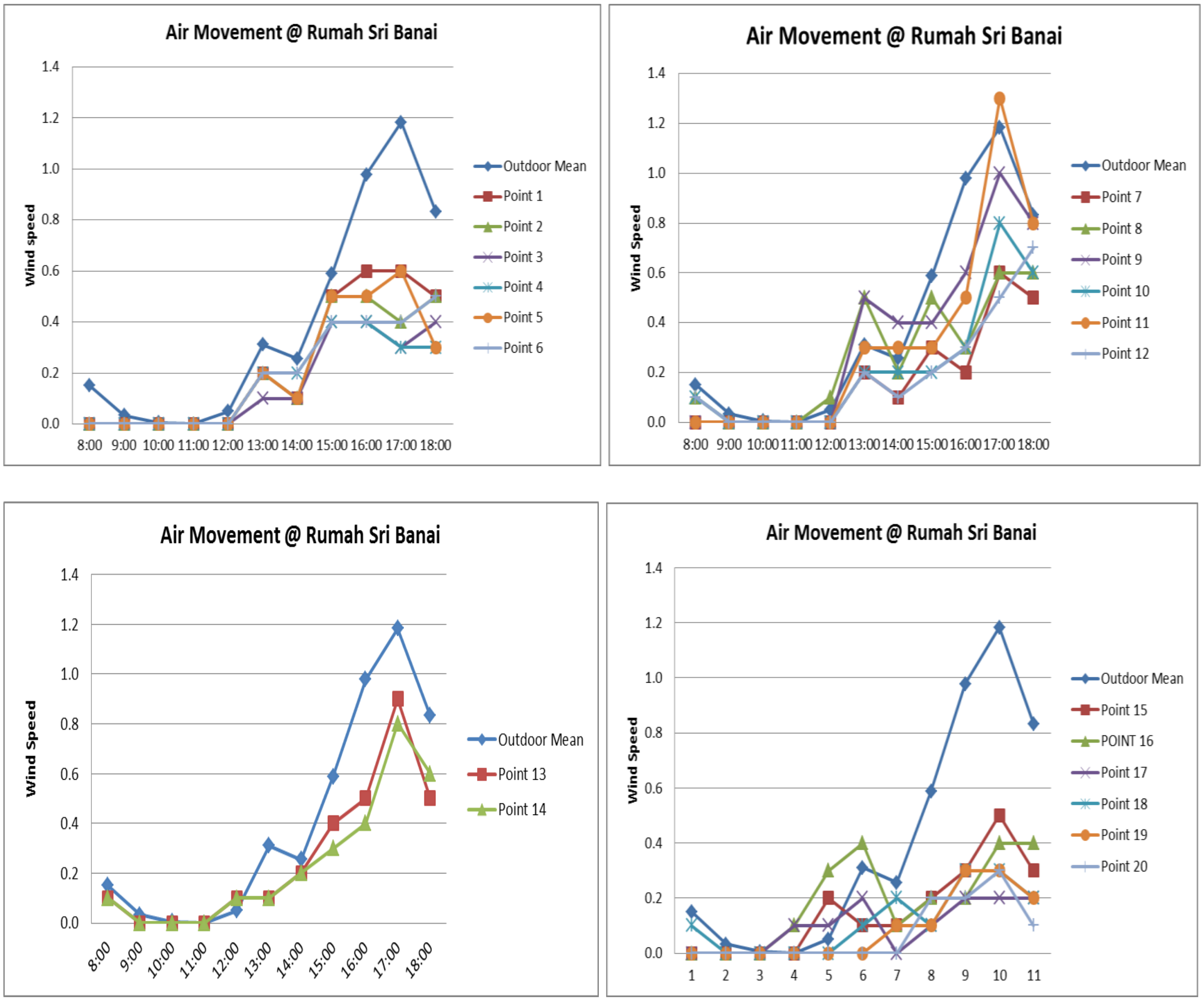

Figure 12: Graph of Wind Speed against Time for Sri Banai House

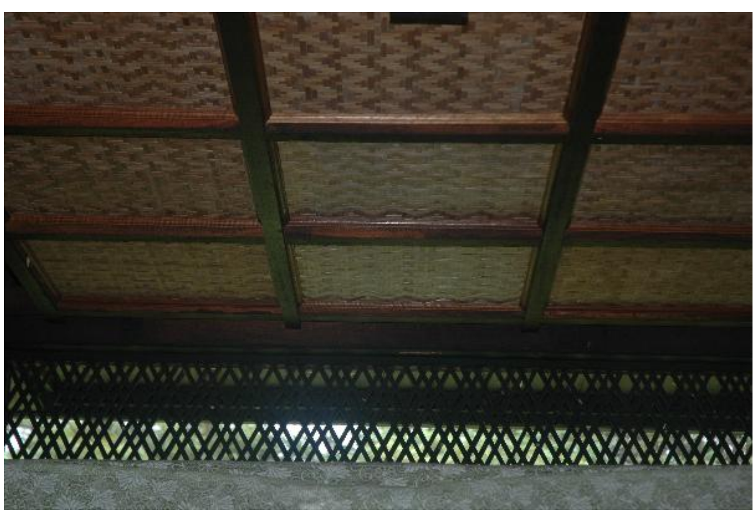

Figure 13: Ventilation openings under roof

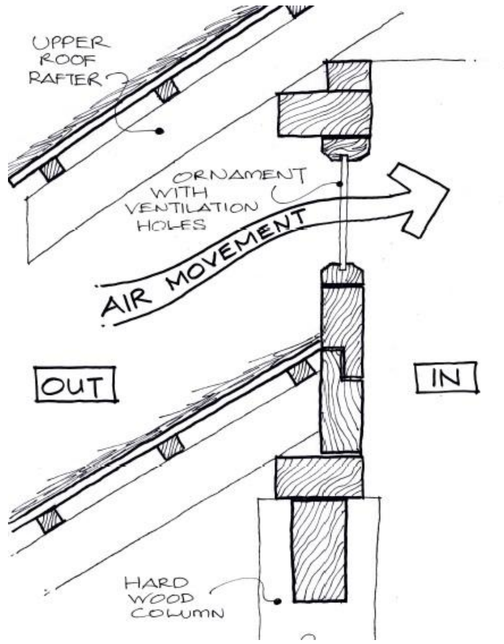

Figure 14: Air Movement Flow between Roofs

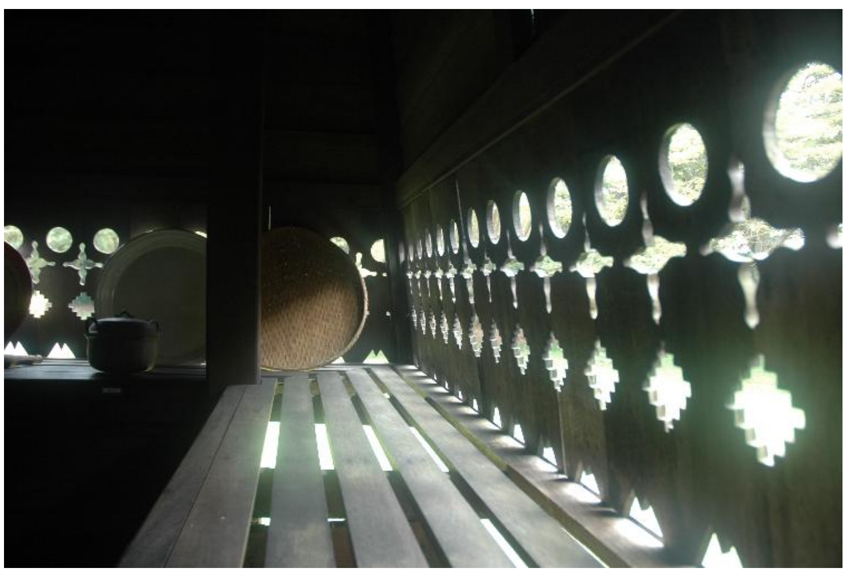

Figure 15: Shelves with Ventilation Openings

Discussion

Based on Beufort Scale to identify the level of wind performance, both houses are categorized well in their indoor ventilation performance. Average of 0.2m/s to 0.5m/s for both houses is under 'Light Air' level, which is good enough for residential houses [2]. Proper landscape setting for Kampung Warisan may become one of the main factors for the scenario. Huge lawn area with shady trees without bushy shrubs allow maximum cross ventilation flow with less obstruction to bring benefit for the houses [6].

In the aspect of building design, these vernacular buildings prove that the vernacular design with elevated floors, ample number of openings, open concept interior layout with less partition and high roof without ceiling also contributes to the air flow into the building [7]. In most cases, with the help of the various types of ventilation openings, the buildings show their potential to direct the air movement inside. Meanwhile, the high roofs with upper ventilation openings also show possibility where stack effect might happen [8,9]. This is shown in certain time where the indoor air movement is higher compared to the outdoor air movement.

There is scenario when the opening orientation is not directly towards the crossing air flow where the building fails to catch the direct flow. However, with a lot of other openings, the building is still able to allow the air inside indirectly. As far as thermal comfort is concern, any air movement that able to move humidity and pollution away is considered good enough.

4.0 Conclusions

As people started to opt for natural sources to minimize energy consumption, we have to admit that part of the new so called green approach were already around us since years ago. In terms of providing comfort among users in building, vernacular building elements have shown potential to be considered for today's contemporary building [10]. At least in the aspect of encouraging natural ventilation, this research has proven how elevated floors, providing ventilation openings and having high roof with openings do contribute to encourage air movement into building. Besides that, selection of building materials also shows potential in controlling the indoor air temperature, where difference between indoor and outdoor air temperature may also cause difference on air pressure [11]. This is part of the factor to get the air move and circulating. Therefore, vernacular elements may also be used for today's contemporary building.

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