Optimalization of cross ventilation at family room for fisherman flats in Muara Angke, North Jakarta

IP Prijanto, AG Prawata, W Wizaka

Architecture Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia, 11480

Corresponding author: idham.prijanto@binus.ac.id

Abstract. This paper presents the study on one aspect of natural ventilation, which is cross ventilation. The study is aimed to investigate the optimal louvre window type to maximize the wind speed required to enter the room in order to maintain the comfort ventilation inside the room. This aspect is necessary because the vertical housing is aimed for fishermen at Muara Angke that have low income economy and could not afford to pay for excess energy usage for air conditioning. The result shows that not all type of louvre could maximize the wind speed required. The steps of the study is as follows: (1) to study the optimum wind speed required for comfort ventilation, (2) to study the aspects of cross ventilation, (3) to study the optimal louvre window type that can maximize the wind speed required.

Keywords: Natural ventilation, cross ventilation, comfort ventilation, wind speed, louvre window

1. Introduction

Life in Jakarta as the center of the economy makes many Indonesian people choose to migrate to Jakarta to seek their fortune by working in Jakarta. Not only office workers who come to DKI Jakarta because of their jobs, but fishermen also seek their fortune by coming to Jakarta and settling in Jakarta as fishermen who live in coastal areas, namely in Muara Angke.

According to the DKI Jakarta Province's Department of Food, Marine and Agriculture Security (DKPKP) in 2018 there were 22,328 fishermen arriving in DKI Jakarta as workers and 820 fishermen as owners with a total of 23,148 fishermen. According to the fishermen based on an interview, moving to Jakarta will make it easier for them to sell their catch when they go to sea because there are so many Jakarta residents that the food needs of the Jakarta people are a factor why the fishermen move to Jakarta.

Along with the increase in population in DKI Jakarta, housing is the main need of the population. The government continues to make efforts to provide housing with a variety of models such as vertical houses and prefabricated houses with the type of rental or own. But the fishermen did not have enough...
money to buy or make a decent house so they built their own house using wood and bamboo on the banks of the Kali Adem Muara Angke.

Based on the results of the interview, the fishermen were sillem fishermen or green mussel fishermen, they built houses in coastal areas with makeshift materials. According to them the most important thing is that they can sleep under the roof so that it does not get rained on when resting. Although there are several flats that are provided free of charge for example the Buddha Tzu Chi flats with 600 units, but fishermen are reluctant to live in these flats.

That was caused by the location of the flats with the place where the fishermen had parked their boats is quite far. If they want to go to sea they must use public transportation services such as motorcycle taxis and they are reluctant to pay the transportation fee because it is quite expensive for commuting to the parking area of their boats. In addition, the fishermen could not keep an eye on their boats from home during a rainstorm. According to them their boat is the most important thing for them because if there are no boat then they cannot go out to sea and go catching green shells so they will lose their jobs as fishermen if they don’t have a boat.

By looking at the condition of the fishermen’s housing is not in accordance with the concept of healthy occupancy as in the regulations of the Ministry of Health. One aspect of healthy housing according to the regulation of the Minister of Health No. 829 / Menkes / SK / VII / 1999 is natural air exchange [1]. There are several aspects regarding Natural Ventilation, namely Cross Ventilation, Stack Ventilation, Wind Catchers, Mechanical Ventilation. And the most suitable aspect for hot and humid climates is Cross Ventilation [2]. The use of cross ventilation is also in line with the wishes of the fishermen who want their house not to be hot so they can rest inside the house after going to sea in the morning. The use of Cross Ventilation is applied in the family room because that is where fishermen and their families can relax.

There are six factors in the use of cross ventilation. These factors are orientation to the wind, window orientation, window placement, use of wall fins, use of horizontal overhangs, and window type. The use of window types is one of the factors that influence the success of cross ventilation so choosing the type of window with the right openings will help maximize cross ventilation in the family room so that ventilation comfort arises. Comfort of ventilation is influenced by the speed of the wind entering the room and touching the surface of human skin [3].

In hot and humid climates such as tropical climates require at least 2 m/s wind speed in the room so that the comfort of ventilation in the room arises (Figure 1). Therefore, the type of window or opening that is applied to the vertical dwelling for fishermen must be able to enter at least 2 m/s wind speed in the building.

| Table 10.8 | Air Velocities and Thermal Comfort |
|------------|-----------------------------------|
| Air Velocity | 50 | 80 | 160 | 200 | 400 | 900 |
| km/h | m/s | m/s | m/s | m/s | m/s | m/s |
| 10 | 0.1 | 0.2 | 0.3 | 0.2 | 0.5 | 0.2 |
| 40 | 0.5 | 0.2 | 0.2 | 1.0 | 1.0 | 1.0 |
| 50 | 0.6 | 0.25 | 0.8 | 2.0 | 2.0 | 2.0 |
| 80 | 1.0 | 0.4 | 1.3 | 3.0 | 3.0 | 3.0 |
| 160 | 2.0 | 0.8 | 2.8 | 5.0 | 5.0 | 5.0 |
| 200 | 2.3 | 1.0 | 3.3 | 6.0 | 6.0 | 6.0 |
| 400 | 4.5 | 2.0 | 3.9 | 7.2 | 7.2 | 7.2 |
| 900 | 10 | 4.5 | 5.0 | 16 | 9 | 5.0 |

*The values in this column are the number of people that the temperature would have to drop to create the comfortable environment.*

**Figure 1. Comfort ventilation required**

*Source: Heating, Cooling, Lighting: Sustainable Methods for Architects*
2. The methodology

2.1. The method of study

The diagram below shows the methodology applied in this study (Figure 2). The study is basically a literature review of certain built projects that applied the cross ventilation aspects to the building. This study is based on six variables according to Heating, Cooling, Lighting: Sustainable Methods for Architects (2015) which are building orientation, window orientation, linear inlet and outlet, fin walls, horizontal overhang, and window types that may affect the wind speed that enters the building. The diagram below shows the methodology applied in this study.

![Diagram of methodology](image)

Figure 2. The diagram of methodology

2.3. The case study

The study selected is at Muara Angke, a coastal area in northern of Jakarta (Figure 3a, 3b). The regional boundaries of the island is as follows: North Side: 6°06’17.5”S and 106°46’11.8”E. The fishermen and his family are living in a makeshift house (Figure 3c) that is not healthy if according to the Ministry of Health regulation. Therefore the application of cross ventilation is the one of many aspects that are suitable for the fishermen. In order to maximize the required wind speed, louvre window type is essential for hot and humid climate. Therefore the optimization of louvre that can bring the required wind speed is important to maximize the use of the cross ventilation aspect.

![Case study images](image)
3. Result and Discussion

3.1. The optimum wind speed required for comfort ventilation

Based on the Heating, Cooling, Lighting: Sustainable Methods for Architects [3] the comfort ventilation criteria is presented in Figure 4.

![Figure 4. Comfort ventilation criteria [3]](source)

| Air Velocities and Thermal Comfort |  |  |  |
|---------------------------------|---|---|---|
| **Air Velocity** | **SI** | **Equivalent Temperature Reduction** | **Effect on Comfort** |
| **l/s** | **m/s** | **kph** | **°F** | **°C** |
| 10 | 0.1 | 0.2 | 0 | 0 | Stagnant air, slightly uncomfortable |
| 40 | 0.5 | 0.8 | 2 | 1.1 | Barely noticeable but comfortable |
| 50 | 0.6 | 1.0 | 2.4 | 1.3 | Design velocity for air outlets that are near occupants |
| 80 | 1 | 1.6 | 3.5 | 1.9 | Noticeable and comfortable |
| 160 | 2 | 3.2 | 5 | 2.8 | Very noticeable but acceptable in certain high-activity areas if air is warm |
| 200 | 2.3 | 3.7 | 6 | 3.3 | Upper limit for air-conditioned spaces |
| 400 | 4.5 | 7.2 | 7 | 3.9 | Good air velocity for natural ventilation in hot and dry climates |
| 900 | 10 | 16 | 9 | 5.0 | Good air velocity for comfort ventilation in hot and humid climates |
|  |  |  |  |  | Considered a gentle breeze when felt outdoors |

*The values in this column are the number of degrees that the temperature would have to drop to create the effect on comfort.*

For comfortable ventilation, the air flow techniques mentioned above must be used to maximize air flow across the building occupants. Based on Figure 4, it can be seen that comfort in hot and humid climates is at wind speed of 2-4.5 m/s.

3.2. The aspects of cross ventilation

Natural ventilation strategies in tropical climates that have hot and humid weather can use the following strategies:
1. Cross Ventilation  
2. Stack Ventilation  
3. Wind Catchers  
4. Mechanical Ventilation

But if the outside temperature is lower and the wind speed reaches 1.3 meters per second, the most ideal strategy to use is cross ventilation [2]. To look at the realization of these aspects, precedent studies is used to find out natural ventilation strategies used by buildings that have already been built, building selection based on function, natural ventilation strategies, and also location. The buildings are as follows:

| Project Name          | Building Orientation Towards Wind | Window Orientation Towards Wind | Linear Inlet and Outlet | Fin Walls | Horizontal Overhang | Window Type               |
|-----------------------|-----------------------------------|---------------------------------|-------------------------|-----------|---------------------|--------------------------|
| Hachi Serviced Apartment | Yes                              | Yes                             | No                      | Yes       | No                  | Sliding + Louvre          |
| Axis Vanam            | Yes                              | Yes                             | Yes                     | No        | Yes                 | Single Hung + Sliding     |
| Greenpeace Village    | No                               | No                              | Yes                     | No        | No                  | Single Hung               |
| Primrose Street Apartments | Yes                           | Yes                             | No                      | No        | Yes                 | Casement+Louvre           |
| Botanica Khao Yai     | Yes                              | Yes                             | No                      | Yes       | Yes                 | Sliding+Single Hung       |
| Vegan House           | Yes                              | Yes                             | Yes                     | No        | No                  | Double Hung+Louvre        |
| Skyville at Dawson    | Yes                              | Yes                             | Yes                     | Yes       | Yes                 | Double Hung+Louvre        |
| Tudor Apartments      | Yes                              | Yes                             | Yes                     | Yes       | Yes                 | Single Hung + Louvre      |
| Eden at SW1           | Yes                              | Yes                             | No                      | Yes       | Yes                 | Single Hung + Louvre      |
| Wafra Vertical Housing | Yes                              | Yes                             | No                      | No        | No                  | Sliding                  |

Based on the Table 1 above, it can be seen that only two buildings that use all the strategies from the application of cross ventilation are Skyville and Tudor Apartments. But judging from the location of the two buildings, Skyville is in the middle of Singapore as a residential apartment while Tudor Apartments is in the coastal area of Tudor, Kenya. Judging from its location, Tudor Apartments has more similar characteristics of sea breeze on the coast so that the application of Tudor Apartments is more ideal to emulate.
3.3 The optimal louvre window type
Based on the facts above, both buildings also use louvre openings in the building to maximize cross ventilation in the building, therefore the use of louvers becomes a simulated aspect. The variable of the simulation using Autodesk Flow Design is:

1. Louvre formation: Horizontal
2. Opening Magnitude: 10%, 30%
3. Louvre opening angle (in degrees): 15, 30, 45
4. Floor Height: 2,4,6

The type of opening is use for both the inlet and outlet, the result of the simulation is as follows (Table 2).

Table 2. Simulation result

| Variable                        | 10% Opening | 30% Opening |
|---------------------------------|-------------|-------------|
| Horizontal 15 degrees 2nd Floor | 1.851 m/s   | 2.827 m/s   |
| Horizontal 15 degrees 4th Floor | 1.824 m/s   | 2.736 m/s   |
| Horizontal 15 degrees 6th Floor | 1.820 m/s   | 2.629 m/s   |
| Horizontal 30 degrees 2nd Floor | 1.841 m/s   | 2.814 m/s   |
| Horizontal 30 degrees 4th Floor | 1.827 m/s   | 2.734 m/s   |
| Horizontal 30 degrees 6th Floor | 1.816 m/s   | 2.613 m/s   |
| Horizontal 45 degrees 2nd Floor | 1.955 m/s   | 2.832 m/s   |
| Horizontal 45 degrees 4th Floor | 1.850 m/s   | 2.790 m/s   |
| Horizontal 45 degrees 6th Floor | 1.825 m/s   | 2.672 m/s   |

Figure 5. 30% Opening on 2nd floor with 45 degrees louvre

Figure 6. 30% opening on 4th floor with 45 degree louvre
Based on the results of the simulation using Autodesk Flow Design (Figures 5-7), a grating with a 30% opening can be more optimal in entering the wind compared to a 10% opening. On the 2nd floor the most optimal is with an angle of 15 degrees while on the 4th floor and the 6th floor the most optimal is with an angle of 45 degrees. This is only seen from the aspect of the type of openings only, not seen from all 6 aspects related to cross ventilation. The type of opening is both use for inlet and outlet of the building. Thus this type of openings will be applied in a vertical housing design for fishermen in Muara Angke (Figure 8).

4. Concluding Remarks
The study of the optimal louvre window type in order to be applied in an vertical housing has been conducted and the remarks can be conclude as follows:

- The required wind speed inside a room on a hot and humid climate is at 2 m/s.
- The optimal louvre window type to use in 2nd floor is the 30% opening with 45 degrees angle, this type can bring the wind speed inside a room for about 2.832 m/s.
- The optimal louvre window type to use in 4th floor is the 30% opening at 45 degrees angle, this type can bring the wind speed inside a room for about 2.790 m/s.
- The optimal louvre window type to use in 6th floor is the 30% opening at 45 degrees angle, this type can bring the wind speed inside a room for about 2.672 m/s.
References

[1] Minister of Health Regulations of Republic of Indonesia No. 829 / Menkes / SK / VII / 1999
[2] DeKay, M. Brown, G.Z. (2014). Sun, Wind & Light: Architectural Design Strategies 3rd Edition. Hoboken: Wiley
[3] Lechner, N. (2015). Heating, Cooling, Lighting: Sustainable Methods for Architects 4th Edition. Hoboken: Wiley