A study of natural ventilation for traditional market at Sumur Batu, Central Jakarta

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Abstract. The purpose of this research is to study the application of the concept of natural ventilation in traditional market buildings in Jakarta to improve thermal comfort that can affect the convenience of traditional market users. SumurBatu Market was chosen as the object of research because it is one of the traditional markets that does not appropriate the natural ventilation standards. The results to be achieved are natural ventilation components that pay attention to the building form, building orientation, inlet and outlet sizes and locations, and vegetation as a form of optimizing natural ventilation in the market that can improve the convenience of traditional market users. The step of study are as follows: (1) to study the wind patterns on the site, (2) to study the building forms and openings locations to reach the optimum outcome of natural ventilation, (3) to study the result of simulation from several alternative design that have been made according to natural ventilation standards. The results of the analysis will be applied to the site as a form of redesign of Sumur Batu market.

Keywords: traditional market, natural ventilation, thermal comfort

1. Introduction

This study is based on the Sustainable Development Goals for 2030 which focuses on mitigating and adapting to climate change that can save energy use in buildings to support the development of Jakarta as a sustainable city. Traditional markets as a place for human activities are very often used by some urban communities to meet their daily needs. The market was born from the desire of some people to obtain material needs. Besides, traditional markets play an important role as a driver for the development of people's economy throughout the country (Malano, 2011). Traditional markets also have a unique culture that has existed since ancient times in the form of different activities occurring at the same time as buying and selling activities that create patterns of social interaction between traders and buyers in the form of bargaining activities. Therefore, cultural heritage is important to be maintained as an active public space to provide economic opportunities that can gather diverse people. Increasingly the development of the city of Jakarta, population growth will continue to grow resulting in increased consumption patterns of society, so that market management and supporting facilities are needed.

However, the current traditional market conditions are still very poor condition. Dirty, muddy, smelly, and stuffy become people's perception of traditional markets that make visitors uncomfortable. This is due to inadequate natural exhaustion factors that make the market feel hot and stuffy and do not meet the provisions in air circulation planning. According to the Indonesian National Standard of the Ministry of Public Works, the number of ventilation openings is not less than 5% of the floor area of the room that requires ventilation and the window is 20% of the floor area of the room, which can provide sufficient oxygen and avoid the stuffy atmosphere in the building.
Meanwhile, visitors tend to choose to shop at supermarkets because they feel comfortable shopping at supermarkets equipped with air conditioners, clean and spacious shopping areas, organized management systems, and accessible access to meet daily needs. Visitors' interest in supermarkets makes the growth of supermarkets grow rapidly, and this can defeat the existence of traditional markets. This condition can be concluded that there are still traditional markets that do not pay attention to the provisions of natural ventilation in thermal comfort that can create a bad image of traditional markets.

The Sumur Batu Market is a traditional market designated by the DKI Jakarta Government that needs to be improved [1]. This market is managed by PD Pasar Jaya at Sumur Batu Raya, Central Jakarta. The existence of the Sumur Batu Market in the middle of the residential area is very beneficial for the surrounding population to fulfill their daily needs. Consists of 1 floor that accommodates 453 business places consisting of kiosks, booths, and yards with several traders 227 people with an area of ± 3146 m2. This proves that market conditions are very crowded and dense. However, the physical condition of this market is no longer appropriate because it does not meet the guidelines of the National Standards Agency (Figure 1).

At the time of direct observation, traders put the goods out of limits area so that the atmosphere felt is narrow (Figure 2a). Narrow and crowded hallway obstruct visitors from circulating in the market so that the sense of stuffiness is felt as a result of the location of openings that only exist on the ceiling (Figure 2b). Meanwhile, in a wet area, there is no air ventilation or openings at all so there is no air circulation happen in that place (Figure 2c). From the problems aforementioned, the lack of openings for air circulation in the Sumur Batu Market makes the market users feel uncomfortable about the physical and air condition.

The use of passive design is a way of optimizing the potential of the micro-climate in buildings such as natural air conditioning to maintain the thermal comfort of the space to remain good. These basic principles can be carried out through air ventilation [2]. Meanwhile, by paying attention to natural ventilation in a building can improve the comfort that can facilitate human activities daily [3]. Therefore, it is necessary to have a new market design by adhering to predetermined market standards by applying natural ventilation design theory that can increase the convenience of traditional market users.

Based on the theory from the book Heating, Cooling and Lighting Sustainable Design [4], there are four aspects to achieving optimization of natural ventilation in buildings; building orientation, building shape, size and location of inlet and outlet, and vegetation.
Building Orientation
The orientation of the building mass influences the natural passage that enters the building by exposing the direction of the building to the source of the wind. In tropical climate areas, the widest part of the building area should have a north-south orientation.

Building Forms
Determining the shape of the building mass greatly influences direct access to air entering and passing through buildings that follow the wind orientation. Each form has advantages and disadvantages that affect natural ventilation. According to the theory, building mass no. IV is the most effective for natural ventilation (Lechner, 2010:10).

Inlet and Outlet Sizes and Location
The inlet opening not only determines velocity, but also determines the air flow pattern in the room. On the other hand, the location of the outlet has little effect on the air velocity and flow pattern. According to the theory, if the opening is smaller, should usually be the inlet because that maximizes the velocity and that has the greatest effect on comfort. However, the best way to have a good flow pattern is to have inlets and outlets the same size (Lechner, 2015).

Vegetation
Trees and bushes can funnel breeze through buildings. By preventing the wind from spilling around the sides of a building, a few tree or bushes can significantly increase natural ventilation.

This study aims to examine the performance of wind movement patterns on alternative designs that have been created by applying natural ventilation aspects as a form of optimization of air circulation in buildings. With this solution, it is expected to answer the problems that have been found, so that the Sumur Batu Market can be used as a pilot market for traditional markets that require new designs.

2. Methodology

2.1. The method of study
The research method was carried out in 2 stages. The first stage is the method of collecting primary data and secondary data. Primary data was obtained by conducting a survey to the site by conducting interviews with market users, then making observations by measuring the temperature and temperature on the site using an Anemometer (BenetechGM816) and a Thermometer (HTC-1), then doing documentation to strengthen the issue. Secondary data selected and used as research and design guidelines are the National Standardization Agency for Markets (SNI 8152: 2015), a book from Heating, Cooling and Lighting Sustainable Design by Norbert Lechner (2015) and a journal from Natural Ventilation Review and Plan for Design and Analysis Tools by Emmerich, others (2001).

The second stage is the data analysis method which consists of several stages, such as:

1. Analysis of existing conditions
Analysis of existing conditions is the initial stage carried out to determine the actual conditions. This research was conducted to find out the facts based on predetermined standards. This is done in the form of a survey to the location by comparing the SNI for the Market and observing those related to the air, such as air temperature, humidity, and wind speed using digital measurement tools.

2. Analysis of wind pattern
At this stage the climate parameters have been collected and data on wind sources at the site. These results will be tested using Autodesk Flow Design to analyze the wind patterns on the site, so the result will know the shape of the building, the orientation of the building and the placement of inlet-outlet openings on the site so that the wind distribution can be evenly distributed.

3. Analysis with building test simulations based on natural ventilation theory
This stage is the final stage of the research. Simulation testing with several alternative building forms based on theory from the journal Natural Ventilation Review and Plan for Design and Analysis Tools using Autodesk Flow Design to determine wind patterns that affect natural ventilation in buildings, so that you can find out the orientation of the building, the location of openings, the mass of the building,
it's best to maximize the use of cross-ventilation. This research was conducted in order to optimize the use of natural ventilation in buildings.

2.2. The case study
The object of the traditional market chosen for research is Pasar Sumur Batu, located on Jl. Serdang Raya, RT.1 / RW.1, Sumur Batu, Kec. Kemayoran, Central Jakarta (Figure 3). This market is in the middle of a community settlement where this market is very profitable for the surrounding community to meet their daily needs. The problems faced are the physical conditions of the building and natural ventilation that are not in accordance with the applicable standards so that they do not reach the standard of wind speed comfort which should be 0.5-1.0 m/s. However, the average wind speed in this market is only 0.2-0.3 m/s, so it can disturb with the comfort and activities of market users.

Figure 3. Location of (a) Pasar Sumur Batu Market, and (b) its surrounding (Source: Google Maps)

3. Results and Discussion
3.1. The result of climate parameters on site
Based on ASHRAE's comfort scale 55 (2004) [5] is influenced by four factors consist of air temperature, radiation temperature, humidity, and wind speed, as well as the type of activity and type of clothing which are individual factors. Based on a quote by Karyono (1996), a group of people will get the same thermal comfort when they are placed in the same room, with the same activities and clothing [6]. Table 1 are the results of measurements of climate parameters during the research site on March 3, 2020.

| Time   | Temperature (°C) | Humidity (%) | Air Velocity (m/s) | Location  |
|--------|------------------|--------------|--------------------|-----------|
| 09:00  | 29.5 °C          | 85 %         | 0.2 m/s            | chicken area |
| 09:42  | 29.5 °C          | 91 %         | 0 m/s              | fish area |
| 10:39  | 28.8 °C          | 81 %         | 0.2 m/s            | vegetable area |
| 11:10  | 30.7 °C          | 75 %         | 0.8 m/s            | grocery area |
| 12:00  | 31.9 °C          | 61% %        | 1.2 m/s            | outdoor area |
| Avg.   | 30 °C            | 78 %         | 0.4 m/s            |           |

According to Karyono's research discussion (2010), the optimal comfortable temperature scale in Jakarta is between 26.7 °C to 28.3 °C. However, the average temperature in the Sumur Batu Market is as high as 30 °C. This indicates that there is an increase of 2 °C from the standard optimal comfort temperature. Then, health experts recommend air humidity levels in the range of 45% -65% [7]. However, the average humidity in the Sumur Batu Market reached 78%. If the humidity in the room above 65% (RH), then the presence of viruses, fungi, mildew, mites, and bacteria grow rapidly. Furthermore, air velocity in the range of 0.2-0.5 m/s is considered the most comfortable [8]. Wind speed outside the Sumur Batu Market reaches 1.2 m/s, but due to dense market conditions and lack of openings, the market conditions are stuffy because the wind does not spread evenly. The results of this research to prove that there is a need for a new design of the Sumur Batu Market by following the natural ventilation theory to improve the comfort of ventilation to improve the market condition.
3.2. Wind flow pattern analysis
This research was conducted to determine the wind flow patterns that occur around the site by conducting simulations with Autodesk Flow Design software. Simulation results show that the wind source comes from the north side of the building, while the west and south parts of the building are wind negative pressure (Figure 4). The purpose of this simulation is to determine the shape of the building mass to be used and the location of the openings to adjust the wind pattern. In conclusion, mass buildings with elongated shapes will be placed to adjust the shape of the site. Then the location of the inlet will be on the north and east, while the location of the outlet will be on the south and west side of the building.

![Figure 4. Wind flow pattern on site](image)

3.3. Building form Implication, and Inlet-Outlet location
According to the theory, thin-tall mass building (IV) is the most effective for natural ventilation (Lechner, 2010:10), therefore will be placed on the site (Figure 5a). Openings will be placed on each side of the building (Figure 5b). The size of the inlet and outlet openings must be equal so that the amount of wind entering the same as the wind coming out. The inlet opening is on the north, and east sides if possible. This function acts as the entrance of a source of wind from the north. Meanwhile, the south and west sides are the outlet opening as a pathway for wind flow comes out from the building. This goal is to maximize the role of cross-ventilation working optimally.

(a) (b)

![Figure 5. (a) Thin-tall mass building on site, (b) openings location.](image)

3.4. Simulation form mass
After determining the shape of the mass of the building and the location of the openings, three alternative forms of the building on the site will be made and simulated to determine the nature of the wind that occurs in the building and to determine the wind speed that has reached the required. The approach in making alternative forms is based on the book Natural Ventilation Review and Plan for Design and Analysis Tools, (Emmerich, et al. 2001) [11]. This test is performed using Autodesk Flow Design software. This activity will be used as a hypothesis in designing buildings that will be redeveloped at the design stage. The following are the results of the simulation of the research utilizing the forms, such as Wind-Driven Cross Ventilation (Figure 6, Table 2), Bouyancy Stack.
Ventilation (Figure 7, Table 3). Elaboration of the Basic Strategies Type (Figure 8, Table 4). Based on those simulations, the analysis scoring result is shown in Table 5.

### 3.4.1 Wind-Driven Cross Ventilation

**Figure 6. Wind-Driven Cross Ventilation Type**

| No. | Illustration | Result |
|-----|--------------|--------|
| 1.  | ![Illustration](image1) | This building only relies on the use of a cross ventilation system with a roof that is not concrete without voids in accordance with the combination of approaches used. Openings are placed on the north, east and south sides. Column placement can be used as the width of the inlet and outlet openings. |
| 2.  | ![Illustration](image2) | The wind pattern appears to enter through the building's ventilation openings. On the ground floor, it can be seen that more wind patterns enter because there is less soil than the other floors. |
| 3.  | ![Illustration](image3) | Based on the simulation results, the wind pattern that occurs is laminar which spreads to each floor. However, only small part of the floor building area got the wind. The average wind speed is about ± 0.65 m/s |

### 3.4.2 Buoyancy-Driven Stack Ventilation

**Figure 7. Buoyancy-Driven Stack Ventilation type**
Table 3. Bouyancy-Driven Stack Ventilation Type Test Result

| No. | Illustration | Result |
|-----|--------------|--------|
| 1.  | ![Image](image1.png) | The wind pattern seen on each floor spreads well because of the voids in the middle of the building which can facilitate air circulation. At the top of the roof, you can see the wind coming out through the raised roof hole. |
| 2.  | ![Image](image2.png) | The wind from the east side of the building, entering the building and then rising through the roof hole above it due to the use of stack ventilation. |
| 3.  | ![Image](image3.png) | Based on the simulation results, the effect of a smooth wind circulation occurs in the middle of the building. Then the wind circulation becomes smooth because of the stack ventilation effect so that it can accelerate air exchange through the roof hole. The average wind speed is about ± 0.88 m / s |

3.4.3 Elaboration of the Basic Strategies

Figure 8. Elaboration of the Basic Strategies type

Table 4. Elaboration of the Basic Strategies Type Test Result

| No. | Illustration | Result |
|-----|--------------|--------|
| 1.  | ![Image](image4.png) | After making the building shape with the 3rd application, it was seen that there were areas with poor wind circulation. |
Furthermore, the wind on the east side of the building shows the wind pattern entering the building then rising through the roof hole above it due to the use of stack ventilation.

Based on the simulation results, the use of the 3rd approach is less effective in being applied to buildings due to the uneven distribution of winds throughout the building area. The average wind speed is about ±0.82 m/s.

### Table 5. Conclusion of Natural Ventilation System

| No. | Natural Component | Ventilation | Wind-Driven Cross Ventilation | Bouyancy Stack Ventilation | Elaboration of the Basic Strategies type |
|-----|------------------|-------------|-------------------------------|-----------------------------|----------------------------------------|
| 1.  | Cross Ventilation | √           | √                             | √                           |                                        |
| 2.  | Stack Ventilation | -           | √                             | √                           |                                        |
| 3.  | Wind Spreading    | -           | √                             | -                           |                                        |
| 4.  | Avg. Wind Speed   | √           | √                             | √                           |                                        |

**Score**: 2 4 3

### 4 Concluding Remarks

As a public facility, many people depend on activities centered on traditional markets. Unfortunately, traditional market conditions are generally very poor and not in accordance with the provisions of the Indonesian National Standard (SNI) for the market. From the research conducted at Sumur Batu Market, it can be concluded that it is necessary to design a market in accordance with SNI and fulfill the needs that refer to each component of natural ventilation. Optimization of natural ventilation in the market is also considered to improve thermal comfort. According to the theory of natural ventilation in Heating, Cooling, and Lighting (2015), corrective steps that can be taken include paying attention to the orientation of the building, the shape of the building mass, the location of openings and vegetation.

By optimizing natural ventilation, wind speed can affect the comfort of the human body during activities. To add comfort in the market, wind gusts with a speed of 0.5-1.0 m/s are needed so that market users can feel cool in their activities (Building Physics, 2015). Based on the results of the research test, the Buoyancy-Stack Ventilation type (Table 3) is an example of a building shape suitable for use on the site in order to make the best use of the wind. The simulation results in Tables 2-5 prove that the presence of voids in the building will cause the wind to fluctuate to the upper floors. The turbulent nature of the wind indicates that the wind can spread upwards due to voids in the building. Then, the use of stack-ventilation functions to accelerate the process of wind exchange by passing through the roof hole so that the cool and clean wind quality can last a long time in the building. Furthermore, the use of mezzanine floors in buildings can spread the wind more widely so that conditions in the market feel airy.

### References

1. Tempo: PD Pasar Jaya Targetkan 16 Pasar selesai direnovasi akhir 2017, retrieved: 4th February
2. Risnandar, F.F.A. (2019). Kenyamanan Termal dan Kepuasan Pengguna Ruang Kelas di Gedung Kampus ITSB. Journal of Applied Science. 1(1). 012-021.
3. Karyono, T.H. (2010). Kenyamanan Termal dalam Arsitektur Tropis. Arsitektur dan Kota Tropis Dunia Ketiga: Suatu Bahasan tentang Indonesia. Jakarta: PT Raja Grafindo. 1-8
4. Lechner, Norbert. (2007). Heating, Cooling and Lighting Sustainable Design Methods. Jakarta: Rajawali Pers.
5. ASHRAE Standard 55. Thermal Environmental Conditions for Human Occupancy. USA: ASHRAE, 2004.
6. Karyono, T.H. (1996). Arsitektur, Kenyamanan Termal dan Energi. Kuliah Terbuka Jurusan Arsitektur, Universitas Soegrijapranata. Semarang: Universitas Soegrijapranata.
7. Tingkat kelembapan ideal, retrieved 4th March 2020, https://www.higienis.com/blog/humidity-guide/
8. Frick, Heinz. (2008). Ilmu Fisika Bangunan. Yogyakarta: Kanisius.
9. Malano, Herman. (2011). Selamatkan Pasar Tradisional: Potret Ekonomi Rakyat Kecil. Jakarta: Gramedia.
10. Sustainable Development Goals No.11, United Nation retrieved: 28th March 2020, https://sustainabledevelopment.un.org/
11. Emmerich, dkk. (2001). Natural Ventilation Review and Plan for Design and Analysis Tools. U.S. Department of Commerce, National Institute of Standards and Technology. 64