The Effect of Local Wind Speed for Opening in Mega Kuningan Highrise Office Tower

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Abstract. Along with the development of cities, the need for offices has never decreased. The data shows an increase in demand for office space every year. Unfortunately, the increasing need for multi-storey buildings is not matched by health issues for the people who work there, so there are many Sick Building Syndrome phenomena. Especially with the conditions during the Covid-19 pandemic, where many tall buildings became clusters of sufferers caused by poor air circulation. Therefore, this study aims to determine the optimal opening size for hybrid ventilation - a combination of natural ventilation with artificial air circulation - which will be applied to rental office buildings in South Jakarta. This research uses quantitative methods with Autodesk Flow Design software simulation that takes into account wind speed to determine the air change per hour in each floor. The result of this research is the dimensions of openings in leased office buildings. This research can be used and applied in designing tall buildings around it.

Keywords: sick building syndrome, hybrid ventilation, natural ventilation, air change per hour, opening dimension.

1. Introduction

In line with the increasing value of investment in Indonesia, the need for leasing office space in Jakarta is increasing from time to time. Developers responded to this phenomenon by continuing to build new office buildings in almost all areas in Jakarta. Based on data from the Public Appraisal Service Office (KJPP) RHR (2013), the growth rate of leased office space supply in the last ten years has grown by an average of 4% per year, while the level of demand has increased by an average of 6% per year. Therefore, even though the supply amount is still above the required amount, in the long term there will be a shortage of leased office space [1].

The National Institute for Occupational Safety and Health (NIOSH) USA in their research has reported a group of symptoms of health problems in workers who work in multi-storey buildings called Sick Building Syndrome (SBS). Occupational Safety and Healthy Act (OSHA) research was obtained from 446 buildings, the causes of air pollution in buildings due to inadequate ventilation (52%), tools/materials in the building (7%), outdoor pollution (11%), microbes (5%), building...
materials/office equipment (3%), and unknown (12%). Symptoms that occur are not specific, such as headaches, irritation of mucous membranes, eyes and nasopharynx, cough, spasms, rhinitis and other symptoms but are not specific diseases and the cause is not clearly known [2]. Especially during this pandemic, the office has become the main cluster in the spread of the Covid-19 virus. Unhealthy air circulation causes many victims to be exposed from offices, especially offices in high-rise buildings that rely on artificial air circulation.

Therefore, this paper aims to study the application of hybrid ventilation systems in high rise office. The hybrid ventilation systems can be described as systems that providing a comfortable internal environment using both natural ventilation and mechanical systems but using different features of the systems at different times of the day or season of the year. It is a ventilation system where mechanical and natural forces are combined in a two-mode system [3]. This natural airborne system is important, because based on research, good air circulation can reduce the transmission of the Covid-19 virus. Natural Ventilation also plays an important role in reducing energy use in high-rise buildings for air circulation to support the sustainability of the building itself. Although natural ventilation is not fully applied, it can reduce most of the use of artificial air circulation.

2. The methodology
2.1. Collecting Data

The research method used is quantitative research methods. Quantitative research emphasizes testing theory through measurement of research variables with numbers and conducting data analysis with statistical procedures [4]. Quantitative variables in this study are the results of measurements of wind speed in the District of Setia Budi in South Jakarta at an altitude level from the low to the high zone. The results will be used to calculate roughness class and roughness length in the area. This roughness rating will be entered in the wind speed calculator from Soren Korhn and the Danish Wind Industry Association [5]. Measurements were made to the environment around the building, at 3 different measurement locations to get the average wind speed. The location of the measurement is also carried out in the low zone, middle zone and high zone. Data collection time was carried out in the morning, afternoon and evening time ranges.

Furthermore, analyzing the highest wind speed based on the direction of the coming wind with the Global Wind Atlas. After that, an analysis of the shape of the building mass will be carried out to find the basic form in accordance with land regulations and wind speed in the building mass using the Autodesk Flow Design software.

Air changes per hour is very influenced by process of the moving air particles in the room and replacing them with new air particles by using a opening as cross-ventilation. Variable of the change of air consists of ‘N’ is the value of air change for each hour (ACH), ‘Q’ is the volumetric flow rate (volume of air entering the room) (m³/s), ‘V’ is the volume of the room or building (m³), 3600 is a conversion factor (from second to hour) [6]

2.2. Location of Studies

The study selected according to the project and zoning for office buildings, trade and services on Jl. Perintis No.9 RT.3 / RW.1, Kuningan, Setiabudi District, South Jakarta City. Determination of typical floor area requirements is based on a 20-30-meter span space where the efficient area per floor is 1000 m² [7].

- Area per typical floor: 1050 m²
- Area per podium floor: 1500 m²
- Total number of typical floors: 18 floors
- Total number of podium floor: 3 floors
- Total area typical floor: 18,900 m²
- Total area podium floor: 4500 m²
- Total area of building: 23,400 m²
Figure 1 shows the visualization of site index in the area. The location of study is marked by color buildings.

![Figure 1. Site index of project and surrounding buildings](image)

3. Result and Discussion

3.1. Wind Speed Data

Based on the results of measurements carried out at three locations in the low zone, mid zone and high zone, the average wind speed data are shown in Table 1.

| Average Wind Speed | Time: 11.00 AM | Time: 01.00 PM | Time: 03.00 PM |
|--------------------|----------------|----------------|----------------|
| Low Zone           | 2,56 m/s       | 2,05 m/s       | 2,28 m/s       |
| Mid Zone           | 3,06 m/s       | 2,16 m/s       | 2,82 m/s       |
| High Zone          | 3,42 m/s       | 3,13 m/s       | 3,12 m/s       |

3.2. Building Simulation

Based on the above site regulation, the maximum number of building layers is 18. Assuming the floor to floor height is 4 meters, the total building height is approximately 80 meters. This height will affect the wind speed, where the taller the building, the higher the wind speed. This wind speed will be measured using the wind speed calculator developed by Soren Korhn and the Danish Wind Industry Association. This wind speed calculator will be able to predict wind speed at each altitude level. Based on the average data input that has been collected above, the wind speed is obtained in Table 2.
Table 2. Wind Speed Calculator

| Roughness Class | Length 0.0002 | 0.0024 | 0.03 | 0.055 | 0.1 | 0.4 | 1.6 |
|-----------------|---------------|--------|------|------|-----|-----|-----|
| 150 m           | 8.84          | 8.32   | 7.60 | 7.38 | 7.15 | 6.51 | 5.7 |
| 140 m           | 8.80          | 8.27   | 7.54 | 7.32 | 7.08 | 6.44 | 5.61|
| 130 m           | 8.75          | 8.21   | 7.47 | 7.25 | 7.01 | 6.36 | 5.52|
| 120 m           | 8.70          | 8.15   | 7.4  | 7.17 | 6.93 | 6.27 | 5.42|
| 110 m           | 8.64          | 8.09   | 7.32 | 7.09 | 6.85 | 6.17 | 5.31|
| 100 m           | 8.58          | 8.02   | 7.24 | 7.00 | 6.75 | 6.07 | 5.19|
| 90 m            | 8.51          | 7.94   | 7.14 | 6.91 | 6.65 | 5.95 | 5.06|
| 80 m            | 8.43          | 7.85   | 7.04 | 6.80 | 6.54 | 5.82 | 4.91|
| 70 m            | 8.35          | 7.75   | 6.92 | 6.67 | 6.40 | 5.68 | 4.74|
| 60 m            | 8.24          | 7.63   | 6.78 | 6.53 | 6.25 | 5.51 | 4.55|
| 50 m            | 8.13          | 7.49   | 6.62 | 6.36 | 6.08 | 5.31 | 4.32|
| 40 m            | 7.98          | 7.33   | 6.42 | 6.15 | 5.86 | 5.06 | 4.04|
| 30 m            | 7.79          | 7.11   | 6.16 | 5.88 | 5.58 | 4.75 | 3.68|
| 20 m            | 7.53          | 6.80   | 5.80 | 5.50 | 5.18 | 4.30 | 3.17|
| 10 m            | 7.07          | 6.28   | 5.18 | 4.86 | 4.50 | 3.54 | 2.30|

The analysis conducted is using Autodesk Flow Design software (Table 3). The wind rose data shows that most of the building comes from 247.5° or the southwest directions. The analysis is done by entering the wind speed data from the wind speed rose data in the software to run the simulation. Based on the simulation, the direction of the wind coming mostly determines the location of the ventilation openings that will be applied to the building. This can be marked by a red arrow where on the side, the wind blows with a certain speed that can be used as natural ventilation in hybrid ventilation.

Table 3. Wind Simulation

| Low Zone | Mid Zone | High Zone |
|----------|----------|-----------|
| Average: 2.602 mps | Average: 2.853 mps | Average: 3.872 mps |

3.3. Calculation of Openings for Hybrid Ventilation

After analyzing the average wind speed of the building, a ventilation opening will be calculated to enter the air from outside so that air exchange occurs. The calculation (Table 4) is done using the formula for air changes per hour or Air Change per Hour (ACH). The standard of ACH value for office is 2 [8].

Formula of ACH [6]:

\[ \text{ACH} = \frac{\text{Volume of the room}}{\text{Air change per hour}} \]
\[
N = \frac{3600 \times Q}{V}
\]  
(1)

Where:
\(N\) is the air change value for each hour (ach)
\(Q\) is the volumetric flow rate (m³/s)
\(V\) is the volume of the room or building (m³)
3600 is a conversion factor (from seconds) to hours.

The natural ventilation rate (Q) is obtained using the formula:

\[
Q = 0.025 \times A \times v
\]  
(2)

Where:
\(A\) is the opening area (m²)
\(v\) is the wind speed at the opening (m/s),
and 0.025 is a multiplier

| Zone         | Area of Openings      |
|--------------|-----------------------|
| Low Zone     | 34.16 m²              |
| Middle Zone  | 31.16 m²              |
| High Zone    | 22.96 m²              |

4. Concluding Remarks

Based on the results of the review, it can be concluded that ventilation is very influential on the problem of sick building syndrome (SBS) which is a symptom of a health disorder that is generally associated with the respiratory tract. Air change plays a central role in reducing the level of indoor air pollution emitted from the indoor environment or produced by occupant activities. Table 5 shows the results of the calculation of ventilation openings with the calculation of air change per hour (ACH).

| Zone     | Area of Openings |
|----------|------------------|
| Low Zone | 34.16 m²         |
| Mid Zone | 31.16 m²         |
| High Zone| 22.96 m²         |

Based on the results of the analysis, it can be concluded that the height and volume of the space in the building affect ventilation openings. The higher the zone the smaller the ventilation opening area, because the wind speed in the building vertically from face to height experiences an increased wind speed.
References

[1] Mulyadi, E., Miyasto, H., & Sugiyanto, F. (2015). Model Nilai Sewa Ruang Perkantoran. *Kajian Ekonomi dan Keuangan*, 108-203.

[2] Yulianti, D., Ikhsan, M., & Wiyono, W. (2012). Sick Building Syndrome. *Cermin Dunia*, 21-4.

[3] Heiselberg, P. (2000). *Design Principles for Natural and Hybrid Ventilation*. Denmark: Aalborg University.

[4] Paramita, R. W. (2015). *Metode Penelitian Kuantitatif*. Lumajang: STIE Widya Gama Lumajang.

[5] Soren Krohn & Danish Wind Industry Assosiation. 2003. Wind Speed Calculator. (Obtained 24-03-2020) from [http://wiki.windpower.org](http://wiki.windpower.org)

[6] P.S, E. C., Thojib, J., & Martiningrum, I. (2015). Resort Batu Ampar Bali Dengan Konsep Ventilasi Silang Melalui Rasio Bukaan Ragam Hias. *Jurnal Mahasiswa Jurusan Arsitektur* Vol. 3, 3-14.

[7] Neufert, E. (2002). Data Arsitek. In E. Neufert, *Data Arsitek* Jilid 2 (p. 8). Jakarta: Erlangga.

[8] Recommended Room Ventilation Rates. Smart Air. [Online] [Accessed: 2020 09 20] [https://smartairfilters.com/en/blog/ventilation-rates-office-home-school-virus/](https://smartairfilters.com/en/blog/ventilation-rates-office-home-school-virus/)