Analysis on control of rail noise in Jakarta

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Abstract. The goal of research was to determine the scale of exposure caused by trains, especially in office buildings around railroad tracks. This research involves direct measurement, namely by measuring the rail equivalence index (LEq). The results of the measurement of the noise level for 2 days was 83 dB(A) which means it exceeds the standard noise level that has been set; 65 dB(A). Therefore, consideration is needed involving noise control in office buildings. Noise control focuses on the mass buildings that are formed in accordance with the influence of the wind, in which the shape of the building can accommodate wind flow in controlling railroad noise. From the research that has been done, simulated the shape of the box building and terracing. In conclusion, the form of terracing is the most effective building in reducing noise, since it has wider shading zone.

Keywords: noise, railroads tracks, equivalent index, office, mass buildings, wind

1. Introduction

Nowadays, many office buildings in Jakarta located near the city’s main transportation routes. However few buildings on overcoming external noise to the building. External noise is a major source of noise pollution to the environment, including road traffic, rail traffic and air traffic [1]. Train noise can cause noise that harms the ear as written in Architectural Acoustics by M. David Egan which is 100 dBA (decibels) [2].

Based on preliminary research [3], the measurements of sound values on trains at distances of 10 m, 20 m, 30 m, 40 m, and 50 m were 92.76 dBA, 85.91 dBA, 84.71 dBA, 82.86 dBA, and 81.01 dBA on the street Ambengan Surabaya. From this data, they show it that the noise level is not by the standards. Where, according to Indonesia Environmental Ministerial Regulation No. 48 of 1996 that the noise value limit is 55 dBA to 70 dBA.

There is a difference of 15-20 dBA, which must be reduced - for example, by wind. Wind influences the factor of building a mass building on noise. As written in the journal by Pavol Liptai [4], “Sound waves propagating, in the wind's direction, will be bent downward. In the upwind direction, the sound speed decreases with altitude, sound waves directed upward, away from the ground “, states that sound waves propagate in the wind's direction.

This paper studied the effect of noise of the train in the area of Palmerah which has a train station. The location of the research site is on Tentara Pelajar street, administratively the area is on Kelurahan
Gelora, Tanah Abang District, Central Jakarta. The site is surrounded by public transportation such as the Palmerah train, TransJakarta bus stops, and pedestrian paths.

The main problem is the noise generated by the Palmerah railroad tracks which can provide disturbing effects on a building. The study on how the effect of sound on a building mass is explained here. The objective of this study is to investigate the most optimum building mass to reduce the effect of sound noise of the train by the analyzing the local wind flow.

2. The methodology

2.1. The method of study

Research conducted using quantitative methods, also data processing using simulation. This method is used to understand the noise that arises in the site and overcome existing noise problems. Noise data collection is obtained through a Sound Level Meter (SLM) and digital stopwatch.

The data collected in the study will analyze and become the main target in this study. There are three main activities carried out in the data analysis stage, the calculation of equivalence index (\(L_{EQ}\)) of railroad noise, identifying whether the data got is under the KEP-48/MENLH/11/1996 noise standard, and identifying an effective building shape in reducing noise with simulation (Autodesk Flow Design).

The study diagram can be seen in Figure 1.
2.2 Problem On Site

Noise level data is collected at point A which is located at a distance of 20 meters from the train (Fig.1). The goal is to find out the noise level caused by the train at that distance. The study took 2 days on February 24, 2020 and February 26, 2020.
3. Result and Discussion

3.1. Railway Noise Level Measurement and Calculation

The Palmerah train moves at a speed of 60 km/hour. The measurement position is at a distance of 20 meters. The following is the prediction for railroad counts:

\[
L_{\text{Eq}} = 86.2 + 18.4 \log(S/80) - 11.3 \log(d/25)
\]

\[
L_{\text{Eq}} = 86.2 + 18.4 \log(60/80) - 11.3 \log(20/25)
\]

\[
L_{\text{Eq}} = 86.2 + 0.941 + 1.095
\]

\[
L_{\text{Eq}} = 88.23 \text{ dBA}
\]

This prediction calculation is then proven by calculation data using the SL4010 Sound level meter tool obtained:

| No | Time   | Noise duration (second) | Noise (dBA) | Prediction (dBA) | \(L_{\text{Eq}}\) (dBA) |
|----|--------|--------------------------|-------------|------------------|---------------------|
| 1  | 08.30  | 32                       | 86          |                  |                     |
| 2  | 09.00  | 26                       | 89          |                  |                     |
| 3  | 14.40  | 25                       | 71          |                  |                     |
| 4  | 15.50  | 24                       | 70          | 88               | 83                  |
| 5  | 16.30  | 24                       | 90          |                  |                     |
| 6  | 17.00  | 22                       | 88          |                  |                     |
| 7  | 17.30  | 26                       | 85          |                  |                     |

\[
L_{\max} = 90
\]

\[
L_{\min} = 85
\]

The average noise level measurement at a distance of 20 meters (83 dBA) results in a lower value than the predicted value (-5 dBA). This influence by the speed of the Palmerah train. Because for the conditions on the site, that the train slows down when passing through the site because it is nearing the Palmerah station. The distance between the site and the station is 800 meters. However, the resulting noise still exceeds the allowable noise standard of 65 dBA [6].
3.2 Wind Speed Data

The local wind speed data was taken from the global wind atlas website. It can be seen that wind direction is more dominant coming from the Southwest, West, North and East (Fig 2). As for the average speed on the site in the form of wind that is not too strong (2.95 m/s) (Table 2). Where, the effects of the wind caused can only make the leaves move.

![Figure 2. Windrose and Mean Wind Speed](source: www.globalwindatlas.info)

| Wind Velocity | m/s |
|---------------|-----|
| Maximum       | 3.1 |
| Minimum       | 1.7 |
| Average       | 2.95 |

3.4 Simulation

The simulation was conducted using Flow design, and the first step was to simulate the basic form. The basic form here is a box. Subsequently, the simulation modifies the initial box form into a terracing form. This modification based on a study that a terracing form can resulted more shading area. Table 4 shows the simulation using box form and its results. Table 5 shows the simulation using terracing form and the results.
### Table 4. Simulation using Box Form

| Simulation | Description |
|------------|-------------|
| ![Simulation](image1.png) | In box buildings, the movement of wind / air flow in the body part of the building's mass indirectly causes the shadow zone to be at a low level only. Where, indirectly the incoming sound is reduced but only in the lower-level area. Whereas, if seen from the horizontal wind movement, it is found that the wind is seen stuck on the mass of the building. This condition makes the sound muffled in the body mass of the building too. Therefore, it is necessary to form a mass that directs the wind to move away from the building. Then the formation of building masses is given indentations on certain sides. So that the coming wind can be directed out of the building. |
| ![Simulation](image2.png) |

### Table 5. Simulation using terracing form

| Simulation | Description |
|------------|-------------|
| ![Simulation](image3.png) | In terracing buildings, air movement can be continued upward because building structures are arranged in stages, causing air to have a flexible space when passing through building masses. Shadow zones are also formed on each floor of the building's mass, indirectly this building is the most effective building in reducing existing noise. |
| ![Simulation](image4.png) |

### 4. Concluding Remarks

The study of wind effect mass building has been conducted and the remarks can be conclude as follows:

- The noise produced by the Palmerah train had exceeded the allowable noise level standard of 83 dBA. While the allowable office noise standard is 65 dBA. Then the noise must be reduced by 18 dBA
- The Windrose data shows that the wind movement is more dominant in Southwest, whereas this direction is helping the site to reduce noise because the direction of the sound source with the wind is the opposite. In that case, the focus of the issue is the direction of the wind that coming from the East, as the direction of the wind is toward the sound source
- Alternative noise control uses the concept of building mass formation. Under the upwind theory, sound can be reduced if the wind that blows against the sound waves will form a shadow zone [7]. Then the mass of the building is designed so that the wind is directed to form a shadow zone in the building mass
- From the simulations, the form of terracing are more effective. Because of the higher level of
the building, the shape of the building made away from the noise. This shape also provides a harmonious wind flow, where shadow zones created at each level of the building. Indirectly this formation can reduce noise up to 20 dBA.

- Critical areas concerning terracing bodies are also small. This critical area can later be overcome simply using material with reflecting properties and diffuser. With such a building mass, the material used does not have to use a special material anymore so that the financial costs incurred are not too large.

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