Generating Matlab looping for noise propagation prediction of environmental thermoacoustic design

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Abstract. In the proposal for designing natural ventilation of open tropical houses, environmental noise control is the simultaneous challenge. Nevertheless, the air circulation strategy for refrigerating and dehumidification can accept airborne noise transfer from sources to inside receivers once the wind direction is in the equivalent path as the noise generator. The deal concerning the design for site barrier and maintaining or preserving the tropical building material can help resolve the warm and noise environment instantaneously regardless of the diverse geographic settings. This study generates the model code of the site barrier of the tropical urban on thermoacoustic subjects as thermal and acoustics' incorporated design. Matlab encoding is used for obtaining noise propagation control to support physiological cooling. The representative tropical buildings, Javanese housings are the case for investigating the urban built environments. The results revealed that considering the decomposition by distance remaining to geometrical propagating, the code involved diffraction, ground effect, and mitigation of sound due to atmospheric absorption. The analysis of essential factors results in the diffraction correction code as the most critical looping. The proposed overhang barrier controls the properties of the noise transmission loss and the reduction of estimation error, which causes imprecise noise management.

Keywords: Matlab coding, noise barrier, thermal comfort, urban environment

1. Introduction

When the tropical building design recommends an open strategy, environmental noise will be obstacles to generating natural ventilation. Meanwhile, the porous walls of traditional houses improve to deliver a resolution for this consequence. This cooling and humidification control design allows airborne noise transmission from outdoors to indoors interrupted by air movement from the same noise source. Analyzing the separate degeneration by remaining to geometric circulating, Sakamoto (2015) [1] submitted a production technique of estimating open-air noise spread. It contained the diffraction, ground, and reduction of sound anticipated to air propagation medium absorption. The sound pressure level for A-weighted, the noise transmission from the source point to the projection spot, is analyzed for the proposal’s traffic noise for the tropical house.

This research predicts the deflection of barrier and its ground effect calculation, where the air absorption is also examined as a synchronized factor with distance component as existing noise propagation. The sound levels intensify because of a down deflecting atmosphere, and the outcome is more significant for higher frequencies [2]. It results in the wind significance arrays after 15 to 23 dB(A). The built-up network topographic anatomy adjacent to the source and receiver will result in the air movement's consequence. Meanwhile, the extensive variation of temperature range was revealed to have...
no result assumed the quick spread detachment [3]. With cumulative windward air velocity, deflection into the sheltered urban leeward is also detected to a partial grade only. The process of noise attenuation simplifies through reproduction through computer software [4]. The finding is gained that reducing noise has a modification of 33.7% and is generated fast through simulation. This performance is found from the judgment of the indicator's rate from the noise source and the signal generator from the receiver. The loop strategy on simulation is a manifestation of the iteration method. Some benchmarks observed substantial accelerations for the particular types and distinguished that looping transformations have diverse impacts depending on the interval and accomplishment appliance [5]. Therefore, it necessary to state the range and the requirement of looping generation.

As developed by the previous study [6][7], for traditional housing as tropical building, the environmental psychology alteration set off "Close The Opening" as the best procedure for adapting the critical noise requirement and the individual adjustment as the simplest and the truly flexible method to do. This condition needs analysis of tolerating wind of noise barrier, as the overhang noise barrier. It is useful to control the impact of ground-borne also as an airborne treatment to support occupant physical and mental comfort [8]. However, all the preliminary findings required the generating of coding to predict the dealing physiological cooling.

Figure 1 illustrates the existing condition of the traditional house of Javanese in the urban environment. The denser neighborhood incorporates the noise environment from human movements and traffic disturbance. The past design using original material still be maintained in the disadvantage of airflow. Therefore, in addition to a previous study [9], this study generates the compromising between accelerating the significant wind for thermal comfort and controlling noise through Matlab formulation for the optimized proposed design, as presented in Figure 2.

**Figure 1.** Research Location and Object
(Source: Urban Sketch and Field Survey (2014-2019)).
2. Methodology

This research focuses on analyzing the looping method to simplify the noise propagation through given information of physiological cooling from the overhang barrier as the recommended element to dealing with. There are three correction formulation, such as diffraction, ground effect, and atmosphere absorption. The house model, geometrically, refers to the initial and previous study [6]. As well as constraints for the type of ground and air absorption, the model proposes two modifiable parameters which have to be determined as of field study at two scales or elevations [10]. Furthermore, this study generates Matlab as a predictor for noise propagation prediction. All quantitative information is conducted through an early field survey and taken from this previous study.

2.1 Method for the diffraction correction

The overhang site barrier as a simple barrier will be considered as an effective strategy. Its design can limit high traffic noise and still promote the potential physiological cooling by air movement. For suggested environmental noise management, the site barrier with air movement consideration is the most critical design. This segment examines the projected method for barrier diffraction estimation for the noise propagation method developed in Equation 1 and Figure 3. For quantitative analysis without diminishing the computation's precision, the simple hypothetical barrier in the calculation of diffraction around an overhang barrier is applied. Because of controlling transmission loss for the barrier performance, this study investigates the critical factor of the diffraction correction. This study proposed common and cheap material of site barrier, 150 mm concrete, TL.avg=47), and the absence of estimating the diffraction produced on noise management imprecise.

\[
\Delta L_{diff, i} = \Delta L_d
\]

Where:

\[
\Delta L_d = -20 - 10 \log(C_{spec}\delta) \quad \text{for } C_{spec}\delta \geq 1
\]

\[
\Delta L_d = -5 - 17 \operatorname{asinh}(C_{spec}\delta)^{0.414} \quad \text{for } 0 \leq C_{spec}\delta < 1
\]

\[
\Delta L_d = \operatorname{Min}(0, -5 + (17 \operatorname{asinh}(C_{spec. abs(\delta)})^{0.414})) \quad \text{for } C_{spec}\delta < 0
\]
Meanwhile: $\delta = L - R$

\begin{figure}[h]
\centering
\includegraphics[width=0.7\textwidth]{diffraction_criteria.png}
\caption{Diffraction Criteria (Source: Sakamoto (2015) [1]).}
\end{figure}

2.2. Method for the ground effect correction

The ground effect analysis through flat ground correction is selected and directed to complete the total calculation. This estimation is an iterated prediction as developed by Equation 2. Figure 4 justifies the impact on noise propagation by ground reflection intervention.

$$\Delta L_{\text{grnd}, i} = -K_i \log \left( \frac{r_i}{r_{cl}} \right) \quad \text{for } r_i \geq r_{c, i}$$

$$\Delta L_{\text{grnd}, i} = 0 \quad \text{for } r_i < r_{c, i}$$

Where:

$$K_i = 4.97 H_{a, i} - 0.472 (H_{a, i})^2 + 5.0 \quad \text{for } 0.6 \leq H_{a, i} < 3.0$$

$$K_i = 1.53 \sqrt{(H_{a, i} - 2.94)} + 15.3 \quad \text{for } H_{a, i} \geq 3.0$$

$$H_{a, i} = \frac{H_{i-1} + H_i}{2}$$

\begin{figure}[h]
\centering
\includegraphics[width=0.7\textwidth]{ground_effect_criteria.png}
\caption{Ground Effect Criteria (Source: Sakamoto (2015) [1]).}
\end{figure}

2.3. Method for the correction for atmospheric absorption

Representing the tropical environment in Indonesia, the typical atmosphere which is temperature, 20°C; relative humidity, 60%; static pressure, 101.325 kPa, as described in Equation 3, for absorption correction for the propagation of noise propagation will be potential generated [1]. An intensification of
calculations design for environmental noise propagation includes the contextual climate into the looping estimation [11].

\[ \Delta L_{\text{air},i} = -6.84 \left( \frac{r}{1000} \right) + 2.01 \left( \frac{r}{1000} \right)^2 - 0.345 \left( \frac{r}{1000} \right)^3 \]  

(3)

3. Results and Discussion

3.1. Analysis of the diffraction correction

From the source standing to the receiver projection related to numerous attenuations, the parameter for diffraction analysis explains the noise propagation (Figure 5). The information of the model is described in Grid-scale in a meter. The propagation looping code shows the implementation of a straight track and diffraction path-direct path based on Equation 1. The diffraction at the barrier edge added devices affects the acoustic field distribution behind the barrier. Barrier structures with a substantial outcome on the sound field behind the border must be enticingly overextended both in horizontal and vertical orders [12][13]. The deflected area in the forward-facing of a pointed edge barrier is differed by the edge geometry in the straight path zone for diffraction. It results in the pointed edge barrier delivering the protection for similar noise absorption [14].

```
barrier(z,i)^=NaN;
map2=zeros(Y,X); for k=1:N;
  for i=1:X;
    x=abs(cors(k).^i);
    y=abs(cory(k).^i);
    l=sqrt((i-da)^2+(j-ta)^2); % direct path/the distance from the source to the prediction point [m]
    i=sqrt((i-da)^2+(j-ta)^2)+sqrt((i-corb)^2+(j-tb)^2); % diffraction path [m]
    lr=1-r; % diffraction path/direct path [m]

    if cors(k)==1 & cory(k)==
      map(k)[j,l]=noise(k);
    elseif i==corb & 0.85*(l<1 & j<tb
      map(k)[j,l]=20*log10(0.85*(l<1));
    elseif i==corb & 0.85*(l<1 & 0.85*(l<1))>=0 & j<tb
      map(k)[j,l]=20*log10(sin(0.85*(l<1)*0.414));
    elseif i>=corb & 0.85*(l<1 & j>tb
      map(k)[j,l]=min(0.5+17*sinh(0.85*(0.85*(l<1)*0.414)));
    else
      map(k)[j,l]=noise(k)-8+(20*log10(sqrt((i-de)^2+(j-ta)^2)));
    end
  end
end
if k==1
  map2=map1;
else
  map2=10*log10(10.^((map2/10)+10.^((map(k=1)/10)+10.^((map(k=1)/10))));
```

Figure 5. Looping Code for Diffraction.

Matlab iteration for estimating the looping behavior on diffraction, as shown in Figure 6, the critical model of lowland daytime results in the implementation of diffraction correction. The overhang design on a simple barrier can reduce from more than 70 dBA at the point of noise source into not more than 50 dBA in the receiver point.
3.2. Analysis of the correction for the ground effect

Inquiries of the near-ground noise propagation energy in the air medium revealed that the noise's scattering involves the distinguished device radiation. Further, distributed and multiply exposure reduces with space more gradually than single distributed pollution [17]. The effect of the resistance grounds in the additional attenuation is significantly connected to the assessment indicator. The average value of the additional attenuation does not transform suggestively as the ground effect has altered from softscape to hardscape [18]. For ground effect, looping is developed by characterizing the barrier and the hardscape around it (Figure 7). The looping correction associated with various noise control methods in the propagation from the generator of noise to the projection point is iterated to show the noise performance. The practical intervention attribute between direct and reflected signals results from the ground surface, environmental vibration, and ground-borne noise [15][16]. At the height of 0.5 m from the ground plane's hard surface, the significant attenuation improves as performed by insertion loss for the source point or the position at the receiver.

```matlab
map2=zeros(Y,X);
for k=1:N;
  for i=1:N;
    x=abs(cory(k)-i);
    y=abs(cory(k)-j);
    r=sqrt((i-ds)^2+(j-ts)^2); % direct path/the distance from the source to the prediction point [m]
    ri=sqrt((db^2+td^2+Db^2+J)^2+(j-tb)^2); % propagation distance [m]
    Ha1=abs((db^2+td^2)^2+(j-tb)^2); % the average height of the propagation path/the average of the two heights Ha=1 and Ha at both ends of the considered ground surface along the shortest propagation path [m] after barrier
    Ei=abs((tb+j)/(tb+i));
    gl1=35.1+3.26*(abs(tb-j)/(tb+j))+32.5*(abs(tb-j)/(tb+j))^2+32.2*(abs(tb-j)/(tb+j))^3; % coefficient of Ei for compacted ground
    hE=0.517-0.0503*(abs(tb-j)/(tb+j))^1.3*(abs(tb-j)/(tb+j))^1.9*(abs(tb-j)/(tb+j))^3; % coefficient of Ei for compacted ground
    if Ha1<3 & H1=0.6
      K11=(4.97*(Ha1)=0.472*(Ha1)^2)+5.0; % a coefficient for the excess attenuation due to the 1st ground surface for 0.6 <= Ha1 < 3.0
    else
      K11=(1.53*sqrt(Ha1-29.4))+1.53; % a coefficient for the excess attenuation due to the 1st ground surface for Ha1 >= 3.0
    end
    if Ha1<3 & H1=0.6
      K11=(4.97*(Ha1)=0.472*(Ha1)^2)+5.0; % a coefficient for the excess attenuation due to the 1st ground surface for 0.6 <= Ha1 < 3.0
    else
      K11=(1.53*sqrt(Ha1-29.4))+1.53; % a coefficient for the excess attenuation due to the 1st ground surface for Ha1 >= 3.0
  end
end
```

Figure 6. Noise Propagation of the Diffraction Looping.

Figure 7. Looping Code for Ground Effect.

The looping method on ground effect correction evaluates the barrier performance of hardscape conditions around the noise pathway. As shown in Figure 8, it explains the partial calculation of the
noise propagation. The flat ground generates a small effect on the propagation because of the barrier role.

**Figure 8.** Noise Propagation of the Ground Effect Looping.

### 3.3. Analysis of the correction for atmospheric absorption

Matlab's looping analysis for atmospheric absorption can be the same as formulating the free propagation of noise to the receiver, especially the climate is typical, like in the tropics (Figure 9). A sound wave propagates several complicated interactions through the air medium, ground, and natural-artificial landscape roughness [19]. The outcome of steady enhancement through the previous findings in theories and computational representations and uncertainty in the propagation setting regularly regulates estimation accuracy. These systems will also be practical noise transfer as an airborne path for multipart surroundings such as the architectural design. They accomplished a flat and exposed field; wind interferes with the sound spread [20].

```matlab
map2=zeros(Y,X);
for k=1:X;
    for j=1:Y;
    x=abs(cosy(k)-j);
    y=abs(cory(k)-j);
    if cosy(k)==1 & cosy(k)==1
        map(k)(j,j)=noise(k);
    else
        l=abs & y=0;
        map(k)(j,l)=noise(k)-8-(20*log10(sqrt((l-da).^2+((j-te).^2))/(10000+2*(sqrt((l-da).^2+((j-te).^2))/(10000)))-2);
    else
        map(k)(j,l)=noise(k)-8-(20*log10(sqrt((l-da).^2+((j-te).^2))));
    end
end
end
end
map2=map1;
else
    map2=10*log10(10."*(map2/10)+10."*(map(k-1)/10)+10."*(map(k)/10));
end
end
```

**Figure 9.** Noise Propagation of the Ground Effect Looping.

The proposed noise control in atmospheric absorption looping is useful to investigate building envelope properties through a non-barrier transmission loss strategy. The implemented equation applies as the looping method for distance path calculation. Figure 10 illustrates the example of the prediction of the atmospheric absorption using Matlab.
3.4. Total noise propagation

The enhancement of the road noise calculation technique, which involves noise propagation and transmission into the indoor environment, should consider optimal thermal comfort, represented by passive ventilation methods in urban density [21]. The highest sound pressure levels are observed in zones of high density [22]. In this section, the total noise propagation is explained for predicting the urban density environment noise. For integrating the looping analysis, the code generates the loading of all propagation code. In other words, it can be formulated as a map for total propagation or "mapTotal" as the average calculation of "mapALD+mapB1LD+mapB2LD+mapCLD" as a stand for all correction of diffraction, ground effect (before and after the barrier), and atmospheric absorption. To plot the presentation contour can be formatted as coded in Figure 11.

4. Conclusion

Because of the changing environment in the tropic, ventilation design is essential. Therefore, occupants prefer to open the aperture for air circulation needs even if the outdoor situation is noisy. The wind has a critical role in the thermal environment, which for noise propagation with closed distance, wind speed has a little effect on the distance source to the receiver. Outdoor barrier analysis on incorporating thermal performance and noise propagation show the overhang barrier's straight path to the receiver when the lowest wall for both airflow requirements considers leeward area and noise control. The capability of managing road noise and accelerating air movement for ventilation is the additional advantage of the simple and low cost of the overhang noise barrier.

Based on a review of the urban environment's standard, noise and thermal integration should be conducted, indicated that there are no guidelines or regulations. The responses of occupants in this adaptation are affected by both thermal and noise problems. Considering the material cost for the proposed building, this study recommends the calculation code for the overhang barrier based on the element's affordability as a simple barrier. However, the overhang as a barrier has not yet been explored for its material properties and efficient construction expenses. The research suggests analyzing the proposed guidelines for tropical conditions of thermal and noise enhancement costs for recommended future investigation. Besides, air pollution is an important analysis for building and environmental improvement for tropical houses in Indonesia. Therefore, for environmental impact, it should be
integrated with the planning for better environmental architecture. For further works, this study recommends formulating guidelines by developing Matlab for Indonesia and tropical building standards related to noise control with thermal comfort design.

**Abbreviation and Symbols**

| Abbreviation | Symbol | Description |
|--------------|--------|-------------|
| Matlab       | Cspec  | Matrix Laboratory | Coefficient of noise |
|              | Ha,i   | The average height of the propagation path = the average of the two heights Hi-1 and Hi at both ends of the considered ground surface along the shortest propagation path [m] |
| Ki           | r=ri   | A coefficient for the excess attenuation due to the i'th ground surface |
|              | rc,i   | The direct distance from the i'th source position to the prediction point [m] |
|              | ΔLcor,i| Critical distance for excess attenuation due to the ground |
|              | ΔLair,i| The correction related to various attenuation factors in the sound propagation from the i'th source position to the prediction point [dB] |
|              | ΔLf,i  | The correction for atmospheric absorption [dB] |
|              | ΔLdif,i| A function of the path difference for diffraction [dB] |
|              | ΔLgrnd,i| The correction for the ground effect [dB] |
|              | δ      | The diffraction path difference [m] |

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