Assessment on the permissance of noise impact levels from the expansion of Batu Berendam Airport, Malacca, Malaysia

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ABSTRACT

The expansion of existing Batu Berendam Airport, Malacca, Malaysia is required to provide more employment and generate activities that would produce reasonable economic benefits to the community. However, it also has a negative impact as it creates an unavoidable problem for the community since they could be exposed to loud and annoying noises. The noises generated from two main sources: the fixed-wing aircraft operations and ground operations. Accordingly, this study conducted to assess the potential noise impact on the community upon its entire operation when the expansion completed. The environmental noise parameters such as the equivalent sound level ($L_{eq}$) and day-night sound level ($L_{dn}$) were used to verify permittance of noise levels. In fact, with the possible introduction of fixed-wing aircrafts, a cumulative effect of the noises will also affect the surrounding area. Therefore, consideration on the runway length of this airport must be count up to provide safe landings and takeoffs by future aircrafts as well as the consideration of buffer zone at the end of the runway in order to minimize the impact to the surrounding residents.

Keywords: Noise impact; airport noise; equivalent sound level ($L_{eq}$); day-night sound level ($L_{dn}$).

1. Introduction

The proposed expansion of Batu Berendam airport located at latitude 2° 15’ 51” N of the Equator and longitude 102° 15’ 11” E. The proposed site is currently a domestic airport and serves as the centre for Malaysian Flying Academy which still operating as of today since 1987. On the stage of expansion, this airport and especially its control tower replaced and complemented with modern aeronautical devices while the terminal complex reconstructed by a new 7,000 m$^2$ terminal equipped with international standard amenities. To regulate night landing, the runways were protected with better safety assurance during poor weather conditions.

Upon completion of the expansion of this airport, it will be known as Batu Berendam International Airport as the government intends to improve the existing airport runway from 50, 764 m$^2$ to 96, 075 m$^2$, to cater for Boeing 737-400 and Airbus A320 aircrafts. Prior to the implementation of the airport design, there are two essential elements to be considered. First, the considerations must be associated with the needs of the surrounding urban centers which provide the demand for air transportation and the additional examination must be associated with the airport environment (Ashford and Wright, 1992; Edward, 1978). However, the
deteriorating environmental conditions affecting the residents of the surrounding area are inevitable (Schultz, 1972). The increase in the air traffic volume would create more pollution and increase the ambient noise levels. Consequently, the objectives of this study are to determine the acceptable noise levels by the community of the surrounding area and also to suggest any practical mitigation of the airport when it is in full operation.

2. Materials and Methods

2.1 Sampling location

The study sites selected as they suffer the most from the expansion of Batu Berendam Airport and most of them lies within the radius of 3 km from the airport. Noise sampling carried out at five sampling points (Table 1), particularly within the residential district to obtain baseline-noise information, and the length of monitoring was carried out for 1 h at three consecutive periods i.e. morning, afternoon and evening. The proposed sites were selected for noise monitoring as they are most sensitive area and always get complaints from the surrounding residents. The area covering the proposed locations was sufficient to determine the impact from active operation of the aviation activity.

<table>
<thead>
<tr>
<th>Sampling Station</th>
<th>Location (residential area)</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>Taman Sutera Belia</td>
<td>02°16'41.2&quot; N 102°15'28.1&quot; E</td>
</tr>
<tr>
<td>N2</td>
<td>North of the project</td>
<td>02°15'23.1&quot; N 102°15'08.5&quot; E</td>
</tr>
<tr>
<td>N3</td>
<td>West of the project</td>
<td>02°15'15.0&quot; N 102°14'04.0&quot; E</td>
</tr>
<tr>
<td>N4</td>
<td>Taman Angkasa Nuri</td>
<td>02°16'30.0&quot; N 102°15'16.8&quot; E</td>
</tr>
<tr>
<td>N5</td>
<td>Taman Seri Bayan</td>
<td>02°16'41.2&quot; N 102°15'28.1&quot; E</td>
</tr>
</tbody>
</table>

2.2 Noise sampling procedure

The noise levels measured at every five minutes using a digital sound level meter (Pulsar Data Logger Sound Level Meter), which records the noise of the surrounding in decibel (dB). Measurements taken using the ‘A’ weighing in the sound recorder, which acknowledged as a normal weighing element to activate the response of the human ear at various noise levels and frequencies. Noise levels recorded as ‘A’ weighted decibels, represented by the symbol dB (A).

2.3 Formulation and equation

i) Equivalent sound level, L_{eq}

The L_{eq} defined as the equivalent steady state sound level. The L_{eq} usually computed for a 1, 10 and 30 minutes and 1, 8 or 24 hours segment of environmental noise. The L_{eq} can be computed by using the following expression:

\[ L_{eq} = \frac{1}{T} \int_0^T L_U \exp(-0.11A(t)) \, dt \]
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\[ L_{eq} = 10 \log \left( \sum_i t_i \cdot 10^{L_i/10} \right) \]  

Where \( n \) = number of samples, \( L_i \) = noise level in dB (A), \( t_i \) = sampling time coefficient.

ii) Day-night average sound level, \( L_{dn} \)

One of the assessments for the annoyance caused by noise is the day-night average sound level, \( L_{dn} \). At this point, the extent of annoyance due to the various noise sources evaluated in the form of an index. Singal (2005) quoted this measure as a better indicator for psychological disturbances since it gives much higher standards of noise level during night time. The \( L_{dn} \) can be computed using the following expression:

\[ L_{dn} = 10 \log \left( \left( \frac{10}{t_{dn}} \cdot 10^{\frac{L_D}{10}} \right) \left( 1 + \frac{10^{\frac{L_N}{10}}}{10} \cdot \left( \frac{1}{t_{dn}} \right) \right) \right) \]  

Where \( L_D \) is the \( L_{eq} \) for daytime (0700 to 2200 h) and \( L_N \) is the \( L_{eq} \) for nighttime (2200 to 0700 h).

3. Results and Discussion

3.1 Existing noise

Table 2 and 3 shows noise data recorded within one hour at 5 minute intervals before converted into equivalent sound level, \( L_{eq} \) and day-night sound level, \( L_{dn} \) in dB (A). The noise levels measured (Table 2) compared with World Health Organization (WHO) recommendation for the community noise levels. Results for \( L_{eq} \) at day and night time are slightly higher, which typically recognized as the noise levels responsible for the common noisiness in the urban area. Those comparisons show the results of noise levels obtained were above the guideline’s recommended values. For \( L_{dn} \) (Table 3), values of the noise levels recorded during night-time at existing ambient conditions are higher than the permitted value in the WHO guidelines. As a result, to explain the consequences of inconvenience caused by noise, the relationship graph (Figure 1) between the day-night average sound level and the qualitative human response adapted to synchronize the acceptance of the public to the noise was evaluated. From this graph, as the values obtained ranged from 68.66 to 74.08, the noise levels may probably cause a significant adverse impact to the public.

<table>
<thead>
<tr>
<th>Sampling Point</th>
<th>( L_{eq} ) (day-time)</th>
<th>( L_{eq} ) (night-time)</th>
<th>WHO recommendation for ( L_{eq} ) in noise community*</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>63.93</td>
<td>58.41</td>
<td>50 dB(A) night-time (10 pm – 7 pm)</td>
</tr>
<tr>
<td>N2</td>
<td>69.53</td>
<td>60.12</td>
<td>60 dB(A) day-time (7am – 10 pm)</td>
</tr>
<tr>
<td>N3</td>
<td>67.57</td>
<td>56.42</td>
<td></td>
</tr>
<tr>
<td>N4</td>
<td>64.07</td>
<td>55.20</td>
<td></td>
</tr>
<tr>
<td>N5</td>
<td>64.77</td>
<td>54.32</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Adapted from Schedule 1: Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential - Commercial), the Planning Guidelines for Environmental Noise Limits and Control (Department of Environment, 2005)
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Table 3: Day-night average sound

<table>
<thead>
<tr>
<th>Sampling Point</th>
<th>Ldn (dB (A))</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>68.66</td>
</tr>
<tr>
<td>N2</td>
<td>74.08</td>
</tr>
<tr>
<td>N3</td>
<td>71.57</td>
</tr>
<tr>
<td>N4</td>
<td>68.51</td>
</tr>
<tr>
<td>N5</td>
<td>71.28</td>
</tr>
</tbody>
</table>

Note: Ldn recorded based on daily average sound level from 7am – 10pm and 10pm – 7am

3.2 Aircraft noise simulations

Since this airport designed to cater for Airbus (A320) and Boeing 737-400 operations, most of the people who live within the 3km radius are becoming more concerned about the impact of the noises that would be generated. In order to simulate the allowable limits of airport noises, a prediction on the L\text{eq} and L\text{dn} values for the proposed airfield runway employed by making an estimate of 37 day-time operations and 1 night-time operation. The model for the estimated impact from operations analyzed either using impulse sources model or continuous sources model whichever is appropriate.

Analysis 1: Calculation based on impulse sources

\[ L_{dn} = SEL + 10 \log (N_d - 10 N_n) - 9.4 \quad [\text{Eq. 3}] \]

Where, L\text{dn} = day-night average noise level, SEL = maximum sound exposure level occurring for single event (150 dB), N\text{d} = number of day-time (0700 – 2200 h) operations, N\text{n} = number of night-time, (2200 – 0700 h) operations. Therefore, total number of operations is 38 per day (1000 per month / 26 days). Number of daytime operation, N\text{d} was estimated as 70 % of the total registered aviation schedule while night-time operation are 30 % from the total registered aviation schedule. The estimated day-time and night-time operation is N\text{d} = (38 x 70%) = 26.6 and N\text{n} = (38 x 30%) = 11.4. Subsequently, the solution on day-night average noise level using impulse sources is L\text{dn} = 3,173 dB (A) [150 x 10 log (26.6 + 10 (11.4)) –
49.4]. From the result, model from impulse sources is irrelevant since the sound exposure level predicted is very much higher than the maximum for existing aircraft operations. Accordingly, continuous sources model were analyzed.

Analysis 2: Calculation based on continuous sources

Determination on day-night average noise level using continuous sources was accounted equivalent sound level, $L_{eq}$ at the first stage. The equation is;

$$L_{eq} = AL + 10\log D - 35.6 \quad [Eq. 4]$$

Where,

- $AL$ = maximum A-weighted sound level of event, 150 dB (A)
- $D$ = event duration within 1-hr period, sec (38 per day / 4 event per hour = 9.5)
- $D_d$ = event duration during daytime (0700 – 2200 hr), sec
- $D_n$ = event duration during nighttime (2200 – 0700 hr), sec

Therefore, the equivalent sound level, $L_{eq}$ is;

$$L_{eq} = 150 + 10 \log 9.5 - 35.6$$

$$= 124.2 \text{ dB (A)} \quad \text{--- (maximum noise prediction at 0 distance)}$$

Then, using continuous sources model, day-night average noise level, $L_{dn}$ was calculated as;

$$L_{dn} = AL + 10\log(D_d + 10D_n) - 49.4 \quad [Eq. 5]$$

Where,

- $AL$ = 150 dB (A)
- $D_d$ = 38 per day / (12 hours x 9.5 event per hour) = 0.33
- $D_n$ = 38 per day / (12 hours x 4.75 event per hour) = 0.67

Thus,

$$L_{dn} = 150 + 10 \log (0.33 + 10(0.67)) - 49.4$$

$$= 109.1 \text{ dB (A)} \quad \text{--- (maximum noise level prediction at 0 distance)}$$

Since equivalent sound level, $L_{eq}$ is much higher than day-night average noise level, $L_{dn}$, the result is significant with current situation. Therefore, the model of Continuous Sources has been considered for the aviation operation during day and night-time.

3.3 Measurement of aircraft noise

In conjunction with airport operation, the main source of noise expected to arise from the aircraft operation itself (Nelson, 1987). People tend to be disturbed by the noises produced by the aviations and landings of the aero planes which are more severe. As a consequence, noise measurements should be carried out to make sure that the noise levels within the surrounding areas would normally be lower than the recommended noise exposure limit. Therefore, permittance noise level measurement should be carried out.
i) Perceived noise level

To compare noisiness of aircraft, a method involving perceived noise level measured in PNdB (Noys) was developed. This relationship is shown in Figure 2 which tends to calculate the total noisiness $N$, in Noys, over the whole frequency range. The following relation is adopted (Singal, 2005):

$$N = n_{\text{max}} + 0.19 \left( \sum n - n_{\text{max}} \right) \quad \text{[Eq. 6]}$$

![Figure 2: Contours of perceived noise](image)

Where $n_{\text{max}}$ is the greatest value of noisiness, in Noys, which is in the frequency range under consideration, and $\sum n$ is the sum of the noisiness values in all bands. The value of total noisiness $N$ (Table 4), in Noys, over the whole frequency range is counted up as 284.75. Subsequently, the perceived noise level for a single aircraft flyover, $N$, which is measured in Noys, can be converted into the perceived noise level, $L_{PN}$ (dB) through the following formula:

$$L_{PN}(\text{dB}) = 40 + 10 \log_{10} \left( \frac{N}{N_{\text{ref}}} \right) \quad \text{[Eq. 7]}$$

The $L_{PN}$ (Table 5) is depicted at 121.54 dB using Eq. 7. Subsequently, noise certification procedure which so called the effective perceived noise decibel (EPNdB) was calculated (Table 6) based on the following equation:

$$L_{\text{EPNdB}} = 10 \log \left( \frac{1}{n} \sum_{i=1}^{n} 10 \log_{10} \left( \frac{L_{PNi}}{L_{PN}} \right) \right) \quad \text{[Eq. 8]}$$
Similarly, the annoyances affecting human (Miedema and Vos, 2003), beings during the operation period can be developed using Noise and Number Index, NNI (Table 7) which essentially referred on the calculated average peak, noise level (LPN) average and operation period can be developed using Noise and Number Index, NNI (Table 7) which essentially referred on the calculated average peak, noise level (LPN) average and flyovers/events, n. The following equation, therefore, adapted:

\[ \text{NNI} = (\text{LPN})_{\text{average}} + 15 \log n - 80 - \text{Eq. 8} \]

**Table 4:** Perceived noise level, N, of Boeing 737-400

<table>
<thead>
<tr>
<th>L dn (max at 0 distance)</th>
<th>nmax*</th>
<th>Σn*</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>109.1</td>
<td>200</td>
<td>765</td>
<td>284.75</td>
</tr>
</tbody>
</table>

*Note: value obtained from Figure 4

**Table 5:** Perceived noise level, L PN

<table>
<thead>
<tr>
<th>N</th>
<th>L PN</th>
</tr>
</thead>
<tbody>
<tr>
<td>284.7</td>
<td>121.54</td>
</tr>
</tbody>
</table>

**Table 6:** Effective perceived noise, (EPNdB)

<table>
<thead>
<tr>
<th>L PN (dB)</th>
<th>n</th>
<th>Effective Perceived Noise Level, (EPNdB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>121.5355</td>
<td>38</td>
<td>105.7377</td>
</tr>
</tbody>
</table>

**Table 7:** Noise and number index, NNI

<table>
<thead>
<tr>
<th>Peak Noise Level, L (Effective Perceived Noise Level)</th>
<th>n</th>
<th>NNI</th>
</tr>
</thead>
<tbody>
<tr>
<td>105.7377</td>
<td>38</td>
<td>49.43</td>
</tr>
</tbody>
</table>

Consequently, the counted NNI value obtained as high as 49.4. Using the correlation between NNI and annoyance in Figure 3, prediction on the degree of annoyance can occur upon social survey scale carried out, at Heathrow airport in 1961 (Flowerdew, 1972). Hence, as shown by the graph, the value obtained has a reasonable level of annoyance significant to the people living near the airport area. In another word, many people, especially those located at less than 3 km in radius will typically produce an objection to the local council, for any
disturbances associated with the airport activity. Typically, the complaints will only last for a temporary period until the developer provides acceptable mitigation to reduce the noise.

![Graph showing social survey scales on NNI value against annoyance (Mulholland and Attenborough, 1981)](image)

**Figure 3:** Social survey scales on NNI value against annoyance (Mulholland and Attenborough, 1981)

ii) Reduction of aircraft noise
Noise usually can be reduced through distance. A correction factor can be used to calculate the reduction of aircraft noise, which depends on the distance of sampling point as proposed by the formula:

\[
ADJ = k \log\frac{Y}{X} \quad [\text{Eq. 10}]
\]

Where,
- \( K \) = 0.28 (based on airport operations, Goff and Novak, 1977)
- \( Y \) = depends on the distance as proposed, m
- \( X \) = initial assumption (distance) from source, m

Consequently, a zone impact has been chosen for 200 (N3), 325 (N2), 375 (N1), 450 (N4), and 750 (N5) in meter distance. The adjustment factor for zone impact is:

a. Location = N3 (West of the project)
   Distance proposed = 200 m
   Initial distance assumption = 1 m
   \( ADJ = 0.28 \log (200/1) \)
   \( = 0.64 \)

b. Location = N2 (North of the project)
   Distance proposed = 325 m
   Initial distance assumption = 200 m
   \( ADJ = 0.28 \log (325/200) \)
   \( = 0.059 \)
c. Location = N1 (Taman Sutera Belia)  
   Distance proposed = 375 m  
   Initial distance assumption = 325 m  
   ADJ = 0.28 log (375/325)  
   = 0.017

d. Location = N4 (Taman Angkasa Nuri)  
   Distance proposed = 450 m  
   Initial distance assumption = 375 m  
   ADJ = 0.28 log (450/375)  
   = 0.022

e. Location = N5 (Taman Seri Bayan)  
   Distance proposed = 750 m  
   Initial distance assumption = 450 m  
   ADJ = 0.28 log (750/450)  
   = 0.062

For the reduction of aircraft noise, a measurement was counted up based upon the distance proposed and the adjustment factor. Thus, the day-night average noise level, $L_{dn}$ are;

a. Distance proposed = 200 m  
   Location = N3 (West of the project)  
   ADJ = 0.64  
   $L_{dn} = 0.64 \times 109.1$ (maximum noise level prediction at 0 distance)  
   = 70.27 dB (A)

b. Distance proposed = 325 m  
   Location = N2 (North of the project)  
   ADJ = 0.059  
   $L_{dn} = 0.059 \times 109.1$ (maximum noise level prediction at 0 distance)  
   = 6.43 dB (A)

c. Distance proposed = 375 m  
   Location = N1 (Taman Sutera Belia)  
   ADJ = 0.017  
   $L_{dn} = 0.017 \times 109.1$ (maximum noise level prediction at 0 distance)  
   = 1.85 dB (A)

d. Distance proposed = 450 m  
   Location = N4 (Taman Angkasa Nuri)  
   ADJ = 0.022  
   $L_{dn} = 0.022 \times 109.1$ (maximum noise level prediction at 0 distance)  
   = 2.4 dB (A)
e. Distance proposed = 750 m  
Location = N5(Taman Angkasa Nuri)  
ADJ = 0.062  
$L_{dn} = 0.062 \times 109.1$ (maximum noise level prediction at 0 distance)  
$= 6.76 \text{ dB (A)}$

iii) Noise reduction of Boeing 737-400

The expected noise attenuation of Boeing noise level (Table 8) can also be forecast by interpolated values (Table 9) of distance over noise level measured. The result is, as the distance increases, the effective perceive noise (EPN) value decreases which significantly affected by ground absorption such as barriers, wind velocity. The interpolation of noise level predicted based on the sampling distance for each station. For example, N1 located within 375 m away from the centre of aviation full-swing at peak time. It simulated to be increased up to 90.75 dB (A) of noise reduction without any obstacle in front. Therefore, the disturbance of Boeing operation predicted to only 59 dB (A) after traveling the 375 m. The nearest effect of being noisiness located at N3 (west of the proposed runaway expansion). It shows some reduction but still consider as a critical aspect for community perception. This will lead to the next discussion on noise combination.

**Table 8: Level of sound stage of Boeing 737-400**

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Noise level dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>200</td>
<td>96</td>
</tr>
<tr>
<td>400</td>
<td>90</td>
</tr>
<tr>
<td>800</td>
<td>84</td>
</tr>
<tr>
<td>1600</td>
<td>78</td>
</tr>
<tr>
<td>3200</td>
<td>70</td>
</tr>
</tbody>
</table>

**Table 9: Interpolation of Boeing sound**

<table>
<thead>
<tr>
<th>Station</th>
<th>Noise level reduction based on distance, EPN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Operation stage</td>
<td>150</td>
</tr>
<tr>
<td>N1</td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td></td>
</tr>
<tr>
<td>N3</td>
<td></td>
</tr>
<tr>
<td>N4</td>
<td></td>
</tr>
<tr>
<td>N5</td>
<td></td>
</tr>
</tbody>
</table>

iv) Noise level combination

The purpose of noise combination is to demonstrate the expected noise levels from the aviation and other activities when the airport is in full operation. Since the primary noise-
makers at Batu Berendam are the aircrafts, the construction of noise barriers, is becoming of considerable interest. Thus, combination noise levels can be obtained after knowing the expected noise levels (only from Boeing) when in full operation (Table 10).

v) Determination of noise combination levels

Level of noise combination can be found by converting the sound pressure levels, measured in series of contiguous band levels, into a single band level encompassing the same frequency range which recognized as the overall level. This general level can be determined by using the formula given (Istvan and Leo, 2006):

\[ L_{p(OA)} = 20 \log \sum_i^n \left( \frac{L_{pi}}{10^{26}} \right) \text{dB} \quad \text{[Eq. 11]} \]

Where,

- \( L_{p(OA)} \) = Expected combination noise level
- \( L_{pi} \) = Existing noise or aircraft noise

Therefore, the expected outcome of combination level summarized in Table 11. The noise level for the average sampling point in Batu Berendam Airport determined to be at the safe level. This regard to the negative impact of harmful sounds on the human ear that will only occur when the level of sound exceeds 75-80 dB (A). Thus, it encompasses that the operation of full-swing aviation would not degrade the level of people perception regarding noise disturbance. It may affect as disruption to the community, but the increases of sound level up to only 1 dB will not lead to adverse effect during aviation activity. Conversely, in the interest of public safety, mitigation measures must eventually be implemented to reduce this noise level.

<table>
<thead>
<tr>
<th>Station</th>
<th>Existing Noise</th>
<th>Expected noise level when full operation (only Boeing)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( L_{eq} )</td>
<td>( L_{dn} )</td>
</tr>
<tr>
<td>N1</td>
<td>63.63</td>
<td>68.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td>69.53</td>
<td>77.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N3</td>
<td>67.57</td>
<td>71.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N4</td>
<td>64.07</td>
<td>68.51</td>
</tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N5</td>
<td>64.77</td>
<td>71.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

vi) Safety consideration

Since the expected combination noise level for Batu Berendam Airport, when in full operation is greater than the WHO guideline limit, the design of the runway must be carefully considered before the implementation. The design referred on the length of the runway which will affect the safety of the aircraft operations, especially towards the nearest
community. Therefore, to provide safe landings and takeoffs by current and future aircrafts, this runway must be long enough. Accordingly, to resolve those required takeoff and landing lengths, aircraft performance curves have been developed and published by the Federal Aviation Agency (FAA) as a design and planning tool which based on actual flight tests and operational data. With this curve, it is possible to determine precisely the correct takeoff and landing lengths for almost all civilian aircrafts commonly in use, both large and small. In this study, adaptation on the performance curves (Ashford and Wright, 1992) by Federal Aviation Agency (FAA) shown in Figure 4 while the right runway length for the Boeing 737-400 determined by the following conditions: maximum takeoff weight (68,039 kg); normal maximum temperature (30°C); airport elevation (sea level); maximum landing weight (61,235 kg) and effective gradient (0.05%).

Table 11: Determination of combination noise

<table>
<thead>
<tr>
<th>Station</th>
<th>Existing Noise (dB)</th>
<th>Aircraft noise, dB (Boeing 737-400)</th>
<th>Expected combination noise level, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>63.63</td>
<td>27.12</td>
<td>63.75</td>
</tr>
<tr>
<td>N2</td>
<td>69.53</td>
<td>22.72</td>
<td>69.57</td>
</tr>
<tr>
<td>N3</td>
<td>67.57</td>
<td>28.43</td>
<td>67.67</td>
</tr>
<tr>
<td>N4</td>
<td>64.07</td>
<td>25.18</td>
<td>64.17</td>
</tr>
<tr>
<td>N5</td>
<td>64.77</td>
<td>19.98</td>
<td>64.82</td>
</tr>
</tbody>
</table>

Figure 4: Aircraft performance curve (adapted from Ashford and Wright, 1992)

Note: 1 lb = 0.454 kg, 1°F = -17.22°C, 1 ft = 0.305 m

The following content discusses the procedure (Figure 4) of determination on the runaway length of this airport. At the first stage, with the average maximum temperature of 30°C as the starting point, project it vertically until it touches the slanted line parallel to the airport elevation (sea level). Subsequently, develop this point of intersection horizontally to the right until it coincides with the reference line (RL). Then, proceed to the right and up on the
corresponding slanted line, to the intersection, where it reaches a point directly above the aircraft’s takeoff weight 68,039 kg. Project this point horizontally to the left and take the right runway length for takeoff at the left ordinate scale. In this example, a distance of 1935.48 m (6350 ft) required for takeoff. Increase this runway range for effective takeoff angle. The resulting runway length is 6562.5 ft. Finally, convert runway distance to meters which will provide the value of 2000 m. Although the expected combination noise level for Batu Berendam Airport, when in full operation is greater than the WHO guideline limit, in terms of safety issue, it considered being safe for the people of the surrounding areas as the actual runway length is 2135 m. In actual fact, some mitigation measures can subsequently be implemented to reduce this noise level.

4. Conclusion

There have been complaints from the people living near to Batu Berendam Airport due to the higher level of noise produced by bigger planes from military activities in the airport. Therefore, since this airport will cater Airbus (A320) and Boeing 737-400, the people in the surrounding area are becoming more worried on the effect of noises. The discussion on expected noise level to the community only focuses on Boeing 737-400, as there are not many changes of noise level to Airbus (A320) in all calculations. Noise continues to be a significant problem despite the proposed improvements, because of the amount of air traffic is growing, number of airlines and corporate jets is increasing and Airline traffic and noise concentrated at a small number of airports that are also likely to be among the largest airports.

On the other hand, the expected combination noise level when the airport is in full operation will not be particularly significant to the nearest residential area (375m), as the value recorded is below 75 dB (A). However, the noise levels are much higher during night-time, and that will disrupt the nearest living residents. Therefore, appropriate buffer zones must be implemented to mitigate the noises which would include noise barrier, involving the location of buildings and site design.

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