Method based on u test for the applicability of airport noise evaluation

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Abstract. The rapid development of air transportation causes noise pollution to become more serious, resulting in more and more obvious social contradictions. Domestic and overseas scholars have studied different indicators of airport noise, many scholars point out the feasibility of the $L_{eq}$ applied to the noise evaluation of the airport, and give some data and methods, more and more scholars are concerned about the unity of environmental acoustics. This paper adopts the whole day test method by means of the evaluation of ground traffic noise, the three sensitive points of a general airport are used to measure the noise of the measuring instrument, and the error data that is caused by special circumstances. The pioneering use of the u test method is handled, the calculation of the measurement value and the standard limit of the time period of the noise is calculated, the difference between the noise exceeding value and the standard value in different time period was analyzed. Finally, the value of equivalent sound level $L_{eq}$ as the evaluation index of airport noise is pointed out.

1. Introduction

In 2016, the General Office of the State Council issued the Guiding Opinions on Promoting the Development of General Aviation industry, which set the near-term development goal of General aviation in China as follows: to build more than 500 general aviation airports by 2020 and basically realize the long-term blueprint of "connecting every county with every airport". With the rapid development of air transport, the problem of noise pollution becomes more and more serious, which leads to more and more obvious social contradictions.

Zhang Huijuan analyzed the relationship between weighted equivalent continuous sensory noise level $L_{WECPN}$ and equivalent sound level $L_{eq}$, so as to solve the problem of applicable standards for noise control in the area affected by airport noise [1]. Xiao Huihui et al. analyzed the advantages and disadvantages of the domestic noise evaluation index system and improved it, adding two new evaluation quantities of equivalent sound level $L_{eq}$ and exposed sound level SEL on the original basis [2]. Xie Yongxia proposed that $L_{dn}$ and $L_{Amax}$, the equivalent noise level for day and night and the maximum A-sound level, should be used together as the evaluation index of airport aircraft noise [3]. Yu Wuzhou et al. proposed $L_{eq}$ and $L_{Amax}$, the equivalent sound level and the maximum A-level, as the evaluation indexes of aircraft noise in the airport [4]. Li Yuwen proposed that $L_{AMAX}$, the maximum noise level in aviation noise, could be used to modify $L_{WECPN}$, the weighted equivalent continuous sensory noise level, and proposed a perfect airport noise evaluation program [5].

Ground traffic noise equivalent sound level evaluation index in this paper adopts full time detection method, and pioneering u test is used to data processing, it is concluded that different periods over the noise of the differences between standard data size, using INM software simulation validation, the
applicability of the application of equivalent sound level in the airport noise assessment were discussed.

2. Current situation of airport noise index at home and abroad

2.1 Current airport noise assessment

The equivalent continuous sensory noise level is called the $L_{WECPN}$, which is the db. The international civil aviation organization recommends that the world use $L_{WECPN}$ as an assessment of aircraft noise at the airport. The definition of the $L_{WECPN}$ is defined according to the ambient noise environment standard of the airport (GB9660-1988) and the air noise measurement method in the airport around the airport.

$$L_{WECPN} = L_{EPN} + 10 \log_{10} (N_1 + 3N_2 + 10N_3) - 39.4$$

(1)

$N_1, N_2, N_3$ —— flights during the day, evening, and night are divided into three periods determined by the local government, which are usually: 7 to 19 in the day, 19 to 22 in the evening, and 22 to 7 in the next day.

The day-night equivalent sound level ($L_{dn}$) is widely used in airport noise evaluation. The history of $L_{dn}$ adoption in the United States dates back to 1973 [6]. The aircraft noise evaluation quantity proposed in the newly revised "Aircraft Noise Environmental Standard for The Area around the Airport" (which has not been implemented yet) is the day-night equivalent sound level $L_{dn}$.

$$L_{dn} = L_{SN} + 10 \log (N_d + 10N_n) - 49.4$$

(2)

To sum up, both the weighted equivalent continuous sensory noise level $L_{WECPN}$ and the day-night equivalent sound level $L_{dn}$ evaluation index are based on the energy average method to obtain the noise value, but the impact of the noise produced by a single aircraft cannot be accurately reflected. Also, the influence of other noises such as car noise brought by airport operation is not taken into account.

2.2 Indoor environmental noise evaluation

According to the "residential design specification" (GB 50096-2010) and "civil architecture sound design specification" (GB 50118-2010), the two national standards [7-8]. The noise measurement value is modified by the different noise characteristics, so the measurement results need to be on the basis of the aircraft noise.

$$L_{eq} = 10 \times \log \frac{1}{T} \int_0^T 10^{0.1L_A} dt$$

(3)

According to the study, the noise limit of $L_{eq}$ is shown in table 1:

| Table 1. $L_{eq}$ noise limit standard (recommendation) |
|--------------------------------|
|            | day | Night |
| outdoor    | 65  | 55    |
| interior   | 50  | 40    |

3. Analysis of airport noise detection

3.1 Monitoring position

At a general airport B, the monitoring point is set up in three sensitive points around its area. According to the noise measurement requirements, the measuring points are selected for the relatively open location nearby, and the microphone is above 1.2m, which is above 1 m above the surface of the surface.

3.2 monitor

This paper mainly adopts the AWA622828+ type noise statistics analyzer, which is shown in figure 1, and the sound level calibrator is calibrated twice a day, and the measurement of stroke, air flow, magnetic field, vibration, temperature and humidity can affect the measurement results, especially the wind and gas flow.
3.3 Data record
According to the flight plan, the maximum number of flights of the month is 24h, and the test frequency is two seconds per second, and the measurement is a sound A level which records for 24 hours, and records the data in the case of interference. In order to measure the data, the equivalent continuous feeling noise level $L_{WECPN}$ and the monitoring point of the monitoring point each 20 minutes are evaluated.

3.4 Data results
Combined with above, aircraft noise needs to be added on the basis of the equivalent a sound level, and is observed in accordance with the limit value of the 7) 65db and night (22:00:00) 55dB, and the data results and the actual flight of the flight are shown in table 2 (the data that is detected in a small time in each grid)

| Measuring point | Level distance m | Perpendicularity distance m | $L_{WECPN}$/dB | $L_{eq}$/dB |
|-----------------|------------------|-----------------------------|-----------------|-------------|
| N2              | 5200             | 80                          | 77.6 dB         |
|                 | 44 47 48 46 51 56 47 46 51 50 52 48 | 52 54 56 45 56 69 58 61 67 64 68 60 | 61 72 65 62 58 64 73 71 64 64 68 70 | 61 59 57 68 67 61 58 72 64 62 57 69 |
|                 | 73 60 62 67 64 67 58 61 57 60 57 54 | 62 60 55 52 50 51 56 56 49 51 52 47 |

4. U test data processing
The u test is a non-parametric test that evaluates two separate sequential data samples from the same general. Obviously, for the noise data of the airport, the distribution is not the normal distribution, but the randomness and size. Therefore, in comparison analysis of data and standard values of airport noise, the difference size of airport noise data and standard value is analyzed, and the u test method is adopted.

\[ u = \frac{|\bar{X} - \mu_0|}{s/\sqrt{n}} \]  

\[ s^2 = \frac{1}{n} \sum_{i=1}^{n} x_i^2 - \bar{X}^2 \]  

Given significant levels of $\alpha$

\[ P\left\{ |U| \geq u_\alpha \right\} \approx \alpha \]  

\[ P\left\{ \left| \frac{\bar{X} - \mu_0}{s/\sqrt{n}} \right| \geq u_\alpha \right\} \approx \alpha \]

To calculate an instance of a sensitive point N2:

Day:
\[
\overline{X}_1 = \sum_{i=1}^{13} x_i = 69.50 \quad s_1^2 = \frac{1}{n} \sum_{i=1}^{13} x_i^2 - \overline{X}_1^2 = 10.67
\]

Order \( \alpha = 0.95 \), \( u_{\frac{\alpha}{2}} = 1.96 \)

\[|\overline{X} - \mu_0| = 69.5 - 65 = 4.50 \quad u_{\alpha} \times \frac{s}{\sqrt{n}} = 1.78 \quad 4.5 > 1.78\]

It is proved that the data and the standard value of the noise standard are significantly different, and the daytime noise is obviously excessive.

Evening:

\[
\overline{X}_2 = \sum_{i=1}^{6} x_i = 58.2 \quad s_2^2 = \frac{1}{n} \sum_{i=1}^{6} x_i^2 - \overline{X}_2^2 = 19.6
\]

Same thing, \( u_{\alpha} = 1.96 \)

\[|\overline{X} - \mu_0| = 58.2 - 55 = 3.20 \quad u_{\alpha} \times \frac{s}{\sqrt{n}} = 3.54 \quad 3.20 < 3.54\]

It is proved that there is no significant difference between the standard data and the standard value, and the noise is unknown in the evening.

5. INM software simulation calculation comparison

INM (comprehensive noise model) is the method of calculating the noise of the airport noise based on ICAO and SAE, which is used for the analysis and prediction of airport noise. It has the system's noise impact prediction and comprehensive noise contour output, which is the established authoritative airport air noise calculation software.

According to the third section, the \( L_{WECPN} \) the corresponding flight of the different time period, which is used to simulate the sensitive point of N2 in the peripheral sensitive point of the general airport, is used to verify the noise rate of the day and night flight, and verify the validity of the \( u \) test method, Reach the contour map of \( L_{WECPN} \) noise.

![Figure 2. The general airport noise contour map](image)

All day | Daytime | Evening
--- | --- | ---

By cutting the flight of the day and evening, the contribution of the flight of the flight of the \( L_{WECPN} \) measurement is analyzed, and the rationality of the \( u \) test is analyzed.

The \( L_{WECPN} \) is compared with the \( L_{WECPN} \) on the average of the whole day, and analyzes the gravity of the noise in each time period, analyzes the noise pollution situation of the high sensitivity point of the time period, so that the noise control can be treated in the time period of noise pollution, such as reducing the number of times, and setting up special flight programs.

6. Summarize

With the development of civil aviation, the number of airports and the scale of the airport have been developing, and the airport noise evaluation and management of airport operation has become a more and more prominent task. This paper analyzes the characteristics of the main airport noise evaluation indicators, and combines the comprehensive noise evaluation system of China, discusses the applicability of the airport noise using \( L_{eq} \), and can obtain the \( L_{eq} \) in a certain degree can be used as
the evaluation index for $L_{WECPN}$. The other $L_{WECPN}$ is based on the duration of the duration of the execution, and then the energy averages to the result per day. The $L_{eq}$ total interval detection can be done:

1. Both the noise changes of the plane caused by the plane can be reflected, and the dynamic changes of the all-day noise are reflected.
2. Ground traffic noise due to airport operation is also taken into account.
3. The evaluation indicators of noise environmental standards can be achieved, which is conducive to the development of environmental acoustics.
4. Using the $u$ test method, it can be seen that there is a significant difference between the time and night of the day and night, and the noise of the airport is more reasonable.
5. In view of the noise energy caused by different time periods, INM software was used for simulation to obtain the noise isoline and analyze the noise simulation values of sensitive points in different time periods, so as to demonstrate the measured results.

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