Study on the Noise Reduction Effect of Sound Absorption Barrier in Different Frequency Bands

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Abstract. Due to the sound absorption coefficient of the sound absorption barrier in different frequency range is different, so the effect of noise reduction are also different. Simply improving sound absorption coefficient in the low frequency band does not necessarily improve the effect of noise reduction. To want to achieve overall good noise reduction effect need considering the influence of sound absorption coefficient in each frequency band and the noise spectrum distribution in an actual road section, different sound barrier used in conjunction. In this paper, the change of the sound absorption coefficient and the noise reduction effect for the different sound absorption materials is compared by the calculation of the theoretical formula in the different noise frequency band, and get some conclusions.

Introduction

Now, in order to reduce the effect of noise barrier on the reflection of sound waves, usually the reflective sound barrier is replaced by sound absorption barrier, and sound absorption barrier can attenuate the acoustic energy, the reduced energy is the noise reduction of sound barrier, thereby improving the diffracted attenuation. The sound absorption coefficient of sound barrier in different frequency is different, and studies have found that there is a certain function between the noise reduction and the sound absorption coefficient of each frequency range fun[1]. And through the example analysis, it is found that the selection of absorption material is not enough only to look at the average absorption coefficient, the contribution for overall noise reduction is better, when sound absorption coefficient of sound barrier is good in low middle and high frequencies.

The influence degree of the contribution to overall noise reduction of sound absorption barrier’s sound absorption coefficient in different frequency bands, at present, there is no clear explanation. In this paper, the problem is discussed preliminary. The cost of sound absorption barrier is higher than that of reflective sound barrier, the construction units need to consider the performance-price ratio of noise barrier. Currently for noise control engineering, in terms of choosing the sound barrier, only according to the average coefficient of indicators to make rough selection, the research is of great significance to the reasonable selection and production of sound absorption barrier for construction company.

Calculation formula of sound absorption and noise reduction:

\[ \Delta dB = -10 \log \left[ 1 - \sum_{i=1}^{n} \alpha_i \cdot 10^{0.1(L_i - L_r)} \right] \]  

Assuming that f1, f2, f3 each frequency band corresponds to a different Di value, and D3>D2>D1, the appropriate values Di*ai corresponds to the different filling parts, D value is the sum of the fill section below.
Figure 1. The noise absorption contribution of each frequency band under different noise absorption coefficient.

\( a_i \) is sound absorption coefficient under different frequency bands; \( L_i \) is sound pressure level before sound absorption in each frequency band; \( L_T \) is the total sound pressure level before absorption. Formula (2) is a logarithmic function, if the amount of noise reduction want to get the maximum, \( D \) should to reach the maximum value.

where:

\[
D_i = 10^{0.1(L_i - L_T)}
\]  

(3)

By calculating the available:

\[
\sum_{i=1}^{n} D_i = \frac{\sum_{i=1}^{n} 10^{0.1L_i}}{L_T} = \frac{\sum_{i=1}^{n} 10^{0.1L_i}}{\sum_{j=1}^{n} 10^{0.1L_j}} = 1
\]

(4)

According to the results of formula (4), the cumulative sum of \( D_i \) is 1.

The following conclusions can be obtained from the analysis of the figure 1:

(1) The larger the part is filled, the better the effect of noise reduction, when the all is filled, the effect of noise reduction is maximum.

(2) In figure 1, \( D_3 \) is biggest, and under the same sound absorption coefficient, the filled is the biggest, the filled part of the total of, namely the contribution to the total noise reduction is also the largest. Enhance the sound absorption coefficient of the corresponding frequency range of \( D_3 \) value, which can significantly increase the effect noise reduction.

The Analysis of Example

Because there are many different kinds of sound absorbing materials, so the part of sound absorption materials is listed and the parameters of acoustic performance are given in this paper. In order to facilitate the analysis and discussion, the sound absorption material is divided into two groups. The sound absorption coefficient of each frequency range is shown in the figure 2 and figure 3:

Figure 2. The comparison of the sound absorption coefficient in different frequency bands.
In order to study the effect of noise spectrum distribution on noise reduction, is given A, B road traffic noise value, the sound level distributions of the each frequency are shown in Table 1, the total sound pressure level can obtained by formula (4).

Table 1. A, B two roads’ traffic noise spectrum distribution value.

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>250</th>
<th>315</th>
<th>400</th>
<th>500</th>
<th>630</th>
<th>800</th>
<th>1000</th>
<th>1250</th>
<th>1600</th>
<th>2000</th>
<th>Total sound pressure level</th>
</tr>
</thead>
<tbody>
<tr>
<td>dB</td>
<td>62</td>
<td>62.8</td>
<td>65</td>
<td>65.3</td>
<td>67.5</td>
<td>66.8</td>
<td>66.0</td>
<td>65.4</td>
<td>65.0</td>
<td>64.5</td>
<td>75.3</td>
</tr>
<tr>
<td>dB</td>
<td>76.6</td>
<td>80.3</td>
<td>78.8</td>
<td>76.1</td>
<td>75.0</td>
<td>71.6</td>
<td>70.2</td>
<td>69.3</td>
<td>68.5</td>
<td>66.6</td>
<td>85.4</td>
</tr>
</tbody>
</table>

The Di value of each corresponding frequency range can be obtained by the formula (3), as shown in Table 2.

Table 2. A, B two roads’ traffic noise distribution.

<table>
<thead>
<tr>
<th>Frequency (dB)</th>
<th>250</th>
<th>315</th>
<th>400</th>
<th>500</th>
<th>630</th>
<th>800</th>
<th>1000</th>
<th>1250</th>
<th>1600</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.0468</td>
<td>0.0562</td>
<td>0.0933</td>
<td>0.1</td>
<td>0.166</td>
<td>0.1413</td>
<td>0.1175</td>
<td>0.1023</td>
<td>0.0933</td>
<td>0.0832</td>
</tr>
<tr>
<td>B</td>
<td>0.1318</td>
<td>0.309</td>
<td>0.2188</td>
<td>0.117</td>
<td>0.091</td>
<td>0.041</td>
<td>0.0302</td>
<td>0.0245</td>
<td>0.0204</td>
<td>0.0132</td>
</tr>
</tbody>
</table>

The contribution distribution map can be made, as shown in figure 4:
Table 3. The noise reduction of different sound absorption materials (unit: dB).

<table>
<thead>
<tr>
<th>sound absorbing material</th>
<th>Superfine glass wool</th>
<th>Superfine glass wool</th>
<th>Superfine glass wool</th>
<th>glass fiber</th>
<th>Micro hollow brick</th>
</tr>
</thead>
<tbody>
<tr>
<td>noise reduction (dB)</td>
<td>A</td>
<td>7.2</td>
<td>7.0</td>
<td>5.6</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4.1</td>
<td>5.2</td>
<td>5.6</td>
<td>2.2</td>
</tr>
</tbody>
</table>

It can be seen from the table 3, the noise reduction effect of sound absorption material is not the same for different noise spectrum distribution value. In Figure 3: superfine glass with the increase of density, absorption coefficient curve gradually shifts to the low frequency, low frequency sound absorption coefficient is increased, the sound absorption coefficient is decreased in high frequency. In the section of A highway, the noise reduction is the highest for the bulk density 20kg / m³ of superfine glass wool. Contrasted the value of A highway segment, it can be found that the sound absorption coefficient has little effect on the noise reduction in a low frequency band (250-400Hz). In the middle and high frequency, it has a great influence, especially the contribution is the largest in middle frequency band, for the bulk density 20 kg / m³ of superfine glass wool, the material in middle-high frequency band (500-2000Hz) absorption coefficient mostly in about 0.9. In contrast, the sound absorption coefficient increases gradually for the bulk density of 30 kg / m³ and 40 kg / m³ of superfine glass in the low frequency band (250-400Hz), but it has little effect on the noise reduction contribution. In the middle-high frequency band (500-2000Hz), the sound absorption coefficient of each frequency band is mostly distributed around 0.8,0.7, which has great influence on the noise reduction. The effect of noise reduction for bulk density of 20 kg/m³> 30 kg/m³> 40 kg/m³ for supper glass wool.

In the B segment of highway, it can be seen from the figure 4 that the change of sound absorption coefficient contributes greatly to the amount of noise reduction in the low band (250-630Hz), especially in the frequency band of 315Hz, 400Hz, the effect of noise reduction is significantly for improving the sound absorption coefficient, but in the high frequency band (800-2000Hz) the effect is little, if there are several sound absorption barrier for choice that should use the sound barrier which is high sound absorption coefficient in low frequency. Compared to the two sound-absorbing material glass fiber and micro hollow brick which the average coefficient is 0.6, as shown in Figure 2, both of which the difference of the sound absorption coefficient is very big in low, high frequency band, but due to the contribution of sound absorption coefficient for noise reduction is minimal in high frequency band, the micro hollow brick whose sound absorption coefficient is bigger than that of the glass fiber in the low frequency should be elected. It can be seen that the noise reduction of micro hollow brick is bigger 3.7dB compared to the glass fiber from the B of table 3.

Discussion and Conclusion

After analysis and discussion, it can be known that the effect of noise reduction is different for a sound barrier in different sections of highway, it is not necessarily significantly improved the noise reduction effect by enhancing the sound absorption coefficient in the low frequency band, it should be according to the distribution of noise spectrum, the value of the frequency range, to determine the contribution distribution, then adjust or select the appropriate sound barrier.

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References


