SURVEY AND ANALYSIS OF THE BEIJING-SHANGHAI HIGH SPEED RAIL NOISE

Li Lu, Xiaohu Hu, Yu Zhang, Xin Zhou

Appraisal Center for Environment & Engineering, Ministry of Environmental Protection, Beijing, China 100012

e-mail: luli@acee.org.cn

This paper surveys and analyzes the properties of the Beijing-Shanghai high speed railway noise, including the source recognition, the simplification and the attenuation propagation of the noise source, the noise level and the range of the noise influence. The analysis result indicates that the frequency of the peak noise lies in the range of 20Hz~80Hz and 500Hz~2500Hz; the noise level attenuates 3dB with the distance doubles, which conforming sound attenuation curve; the noise reduction of the sound barrier distributes from 5.6dB(A) to 11.7dB(A) yielding the desired results; the railway noise emission meets the environmental impact standards for the sensitive spots in area 4a with the daily traffic flow of 63~81 trains at the speed of 300km/h.

1. Introduction

The cities along this railway line are economically developed areas with dense population. Environmental noise problems get more and more attention. During the preparatory and operation periods, high speed railway noise has been studied by means of noise investigation abroad, experimental analysis, construction supervision and the whole system joint debug. Design of the low-noise carriage, the structures of the railway line, the sound barrier and the noise protection measures have been optimized to reduce the noise pollution. This paper surveys and analyses the recognition, the simplification and the attenuation propagation of the noise source, the noise level, the effect of the noise reduction measurements and the range of the railway noise impact.

2. Characteristic investigation and analysis of the Beijing-Shanghai railway noise

2.1 Noise source identification and equivalent simplification

Previous study[1] proved that the high speed rail noise is made up of the power system noise, the wheel/rail noise, the pantograph noise, the aerodynamic noise and structural noise. All the noise above mentioned can be classified into 3 types: the lower part - the wheel/rail noise and driving device noise, the middle part - the aerodynamic noise and the upper part noise-the pantograph noise, with the height of 0.5m, 2.0m and 4.5m from the wheel, separately.

2.2 Noise characteristic and noise level
The A-weighted equivalent level during the passage is used to analyze the noise emission properties and the noise level according to the national guideline[^1]. The measurement site is located at 25m far and 1.2m high from the running train[^2], the result is illustrated in Fig.1.

1) The wheel/rail noise, aerodynamic noise, the pantograph noise are dominating when the train runs at the speed of 300km/h;
2) For both the subgrade and the viaduct railway at 300km/h, the frequencies of the peak value of the railway noise lies within the range of 20Hz~80Hz and 500Hz~2500Hz;
3) The high speed railway noise result in 78~94dB(A), with the speed of 60~300km/h. (with the measurement site 25m far and 3.5m high from the wheel)

3. Measurement and analysis of the attenuation characteristics

For the typical viaduct and the subgrade railway, noise level of the measurement points, with the distance 15m, 30m, 60m, 90m, 150m and 180m far away from the wheel is measured. As shown in Fig.2, when the train runs at the speed of 300km/h, the noise level attenuates 3dB with the distance doubles for the subgrade railway and the viaduct with the distance of 30m~150m, meeting the attenuation law of the finite line sound source. For the viaduct railway, the noise level measured in 15m faraway from the wheel is 2~3dB lower than that in 30m, for the reason of the acoustic shadow effect.

[^1]: National guideline reference
[^2]: Distance and height from the running train
4. **Noise reduction survey and measurement**

4.1 **Noise control of the sound source**

High speed vehicle body design optimization and engineering structure design optimization have been proposed to reduce the train noise\[6\]. For the CRH380A train, the bullet train with low resistance and large slenderness ratio design have been adopted, and the train noise is reduced by 7 percent. For the CRH380 train, bolsterless bogies are used to reduce the noise by 2.1dB. For the CRH380B train, pantograph is covered by a streamline wind deflector to get the noise reduction by 2.4dB. For the engineering structure design optimization, rail grinding can reduce the noise by 3~6dB, and the common span simply supported beam bridges are used to avoid the secondary structure noise.

4.2 **The noise reduction of the sound barriers**

Metal plugboard type sound barriers, showed in Fig. 3 with the height of 3.05m and 2.05m, are equipped along the Beijing-Shanghai high speed railway. The length of the sound barrier along the entire line is more than 330km, and in some cities such as Beijing, Kunshan, Suzhou, Wuxi and Changzhou, continuous barriers are equipped. In this section, 7 of the sound barriers are evaluated by the A-weighted sound insertion loss ($IL_{Aeq}$), a simplified measurement configuration is shown in Table.1, and the $IL_{Aeq}$ are illustrated in Fig. 4.

![Figure 3. the sound barrier along the Beijing-Shanghai line](image)

**Table 1** the measurement configuration

<table>
<thead>
<tr>
<th>measurement site</th>
<th>structure of the railway</th>
<th>height of the sound barriers (m)</th>
<th>length of the sound barriers (m)</th>
<th>traffic flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>viaduct</td>
<td>3.05</td>
<td>460.65</td>
<td>11</td>
</tr>
<tr>
<td>No. 2</td>
<td>viaduct</td>
<td>3.05</td>
<td>&gt;1000</td>
<td>6</td>
</tr>
<tr>
<td>No. 3</td>
<td>viaduct</td>
<td>2.15</td>
<td>237.76</td>
<td>7</td>
</tr>
<tr>
<td>No. 4</td>
<td>subgrade</td>
<td>2.15</td>
<td>240</td>
<td>6</td>
</tr>
<tr>
<td>No. 5</td>
<td>subgrade</td>
<td>2.05</td>
<td>400</td>
<td>12</td>
</tr>
<tr>
<td>No. 6</td>
<td>viaduct</td>
<td>2.15</td>
<td>490.5</td>
<td>10</td>
</tr>
<tr>
<td>No. 7</td>
<td>viaduct</td>
<td>2.15</td>
<td>1047.8</td>
<td>6</td>
</tr>
</tbody>
</table>
As can be seen in Fig. 4:

1) When the train running at the speed of 300km/h, the noise reduction caused by the sound barrier is 5.6~11.7dB(A) at the measurement site 30m in the horizontal direction and 1.2m in the vertical direction from the wheel.

2) The noise reduction varies as the height changes from the wheel changes, and the largest noise reduction is achieved on the horizontal plane of the wheel.

5. Railway noise impact analysis

The railway noise impact is determined by the engineering characteristics, the background noise and the national environmental noise standards. In this section, the railway noise impact is measured and analyzed for the typical sections and the typical train traffic flow, the result is shown in Table 2. It can be seen that the railway noise emission meets the environmental impact standards for the sensitive spots in area 4a. In this measurement, the daily traffic flow is 63~81 vehicle in each direction, the length of night is 8h, and the height of the viaduct and the subgrade are 10m and 4m, respectively.

<table>
<thead>
<tr>
<th>noise environment functional areas and standards</th>
<th>Nanjing-Changzhou(63 couple/day)</th>
<th>Tianjin-Dezhou (81 couple/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 70dB(A)</td>
<td>&lt;30m</td>
<td>&lt;30m</td>
</tr>
<tr>
<td>Night 70dB(A)</td>
<td>&lt;30m</td>
<td>&lt;30m</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 70dB(A)</td>
<td>&lt;30m</td>
<td>&lt;30m</td>
</tr>
<tr>
<td>Night 55dB(A)</td>
<td>&lt;30m</td>
<td>41~82m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;30m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52~97m</td>
</tr>
</tbody>
</table>
6. Conclusions and suggestions

1) For both the subgrade and the viaduct railway at the speed of 300km/h, the frequencies of the peak value of the railway noise lies within the range of 20Hz~80Hz and 500Hz~2500Hz. The train running at the speed of 60~300km/h generates 78~94dB(A) noise.

2) The railway noise level attenuates 2.9~4.4dB with the distance doubles for both the subgrade railway and the viaduct, which basically meeting the attenuation law of the finite line sound source.

3) Noise reduction, caused by the sound barriers in the position 30m in the horizontal direction and 1.2m in the vertical direction from the wheel, is 5.6~11.7dB(A), basically achieving the expected effect.

4) With the daily traffic flow 63~81 trains at 300 km/h, the impact of railway noise can reach the discharge standard, including the environmental area 4a.

5) Continuous study and sequential monitoring are suggest to get larger noise reduction and adequate preparation for the post-evaluation.

REFERENCES