Research on noise propagation of plateau railway

Shao Lin, Liu Lanhua, Li Yanliang, He Caisong
China Academy of Railway Science, Beijing, China.

Summary

Noise propagation on plateau railway has its own features, because of low pressure, permafrost and so on. The analysis of frequency characteristics of the radiation noise and noise propagation is based on the operation of diesel locomotive in the Lhasa –Shigatse Railway. According to the test, the distribution characteristics of the radiation noise frequency spectrum and noise propagation under different speeds (100km/h~132km/h) in operation of the train are obtained， and these conclusions could provide a basis on noise control of plateau railway.

1. Introduction

Qinghai-Tibet Railway is the longest plateau railway built at the highest altitude in the world. Known as the first extension line of the Qinghai-Tibet Railway, Lhasa –Shigatse Railway went into operation in August 2014. Running over an altitude between 3600 meters and 4000 meters, Lhasa –Shigatse Railway is 253 kilometers long. Built in the seasonal frozen soil zone, it is a single track railway. The railway is in the southwest of Qinghai-Tibet plateau. The test locations were in the wide valley area of Lhasa River at the altitude between 3600m and 3700m.

By far, the study of noise propagation on plateau railway is not sufficient around the world. The existing research on noise propagation mainly aim at the stability of subgrade in permafrost region under the condition with train load. The main experimental studies include the following examples: Taking the Qinghai-Tibet railway as the research object, a three dimensional finite element mathematical model for vehicle-track-subgrade was established.The effect the moving load on the frozen soil subgrade which is freezing, thawing and at iced state were analyzed. [1]; The effects of primary parameters such as travelling velocity, train axle, and subgrade. And the influence of train axle, traveling velocity, and vibration numbers on the permanent deformation is investigated [2]; A complete three dimensional FEM model of the ice-rich permafrost subgrade is accordingly established, providing preliminary sights into degradation tendency of ice-rich permafrost subgrade with low temperature, and train-induced vibration mechanism of warm permafrost subgrade with subsurface ice layer and unfrozen interlayer[3]. The study of environmental noise vibration is not adequate and the pertinent literature is an assessment of Qinghai-Tibet Railway environmental monitoring which includes status monitoring of noise sensitive area and vibration sensitive area, evaluating the influence railway noise makes on the ambient environment during operation periods and proposing measures of vibration damping and noise reduction[4].

According to the experimental study of noise propagation in operation of diesel locomotive in the Lhasa –Shigatse Railway, this paper analyses the noise propagation on plateau railway and tries to provide the basis for noise abatement on plateau railway.

2. Test

The test train was drawn by diesel locomotive under the speed of 100 km/h, 120 km/h and 132km/h, consisting of diesel locomotive（DF4DK）, track inspection car, electrical inspection car and diesel locomotive（DF4DK）.

2.1. Test Condition

The temperature range was 10 ℃ ~ 20℃; Relative humidity range was 40%~85%; Air pressure range was 651hPa~653hPa.

2.2. Test Contents

The microphone positions were on one side at a distance of 7.5 m from the track axis and at a height of 1.2 m ± 0.2 m above the top of rail. And the microphone axis shall always be horizontal and directed perpendicularly to the track.
The measurement quantities for trains moving at constant speed are: the A-Weighted equivalent continuous sound pressure level on the pass by time, $L_{Aeq,T}$ and frequency.

2.3. Test Methods

The test methods were based on "Acoustics — Measurement of noise emitted by railbound vehicle[5] （GB/T 5111-2011）"including Item 6.3.3 — Measurements on accelerating from standstill or decelerating vehicles, Item 7.1 — General, and Item 7.2 — Measurement on vehicles with constant speed, etc.
We used multi-channel data acquisition system to record noise signal.

2.4. Arrangement of Measuring Points

The noise tests were separately operated in railway bridge and subgrade. The railway bridge is 8m in height and the subgrade is 6.7m in height. See Table I, Figure 1 and Figure 2 for the arrangement of measuring points.

Table I. Arrangement of noise measuring points

section	distance from track	height
bridge	7.5	3.5m、1.2m above the rail surface, 1.2m below the rail surface, 3m above the ground
bridge	15	3m above the ground
bridge	30	3m above the ground
subgrade	7.5	1.2m above the rail surface

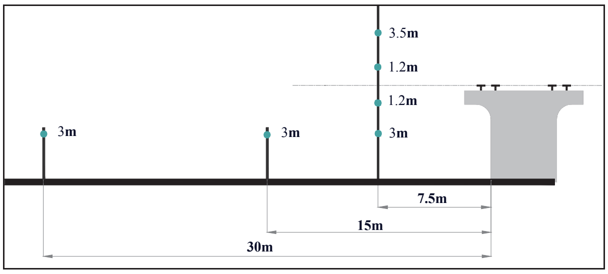

Figure 1. Arrangement of measuring points in railway bridge

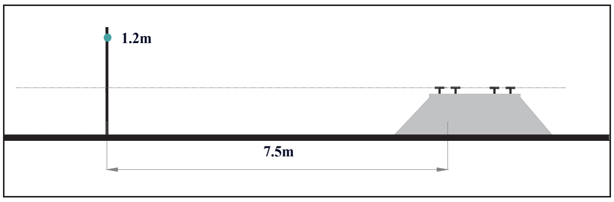

Figure 2. Arrangement of measuring points in subgrade

3. Data analysis

This paper analyses test data from three aspects: The analysis of noise frequency characteristics and noise amplitude, the vertical distribution characteristics of the bridge noise and the horizontal distribution characteristics of the bridge noise.

3.1. The analysis of sound pressure level and noise frequency characteristics

The test point was set at a distance of 7.5 m from the railway bridge and subgrade, and at a height of 1.2 m above the top of rail. The test train was under different speeds (100km/h~132km/h). See Figure 3 for the relation between the sound pressure level and the speed. (Sound pressure level stands for relative sound pressure level in this paper)

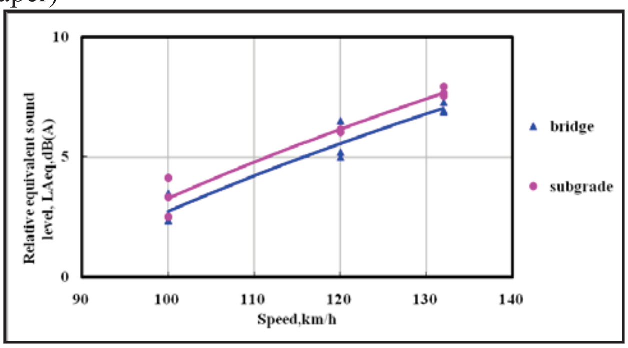

Figure 3. Comparison of noise from bridge and subgrade

The sound pressure level in sections of subgrade was higher than the sound pressure level in sections of bridge. Under different speeds (100km/h~132km/h), the difference value was 0.2 dB(A) ~ 1.1 dB(A).
Noise levels increase with increasing train speed. The A-weighted sound pressure level is usually taken to be proportional to the logarithm of the speed. Based on the analysis of test data, the relationships between the noise level and the train speed are obtained:
The equation of noise level in the section of bridge:

$$L_{Aeq,T} = (35\sim36) \times \lg (V/V0) + C_1 \qquad (1)$$

The equation of noise level in the section of subgrade:

$$L_{Aeq,T} = (36\sim37) \times \lg (V/V_0) + C_2 \qquad (2)$$

Where C_1、C_2 is the sound level at a reference speed V_0, and V_0=100km/h.

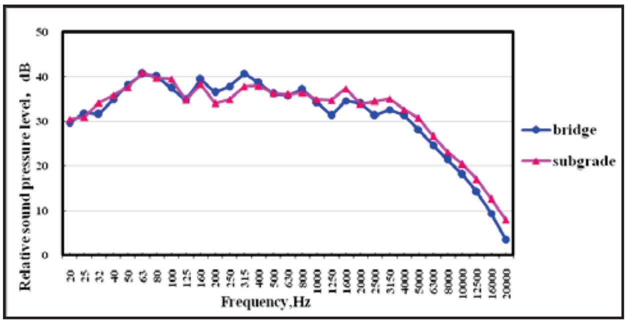

Figure4. Comparison of noise frequency spectrum from bridge and subgrade（v=120km/h）

The distribution characteristics of the noise frequency spectrum shows wideband capacity in the range of 20 to 4000Hz. The maximum sound level mainly centers on low-frequency under 31.5~125Hz. When the noise frequency is over 4000Hz, the sound level gets lower.

3.2. The vertical distribution characteristics of noise from bridge

The test points were set 7.5m from the bridge horizontally and at four different heights: 3.5m above the rail surface, 1.2m above the rail surface, 1.2m below the rail surface and 3m above the ground. See Figure 5 for the relationship between noise level and speed change at diverse height of testing points, under various speeds (100km/h~132km/h) in operation of the train.

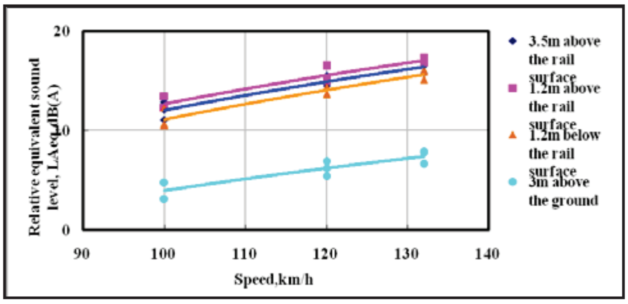

Figure5. Vertical distribution of noise from bridge

In this paper, comparison is made between the noise level received from different height in the section of bridge. The noise level is highest at the testing point 1.2m above the rail surface. When the testing point is 3.5m above the rail surface or 1.2m below the rail surface, the noise level gets lower little by little. The noise level obviously decreases when it's 3m above the ground. The radiation noise mainly consists of the noise in the wheel area.
See Figure 6 for the spectrum noise received from different heights.

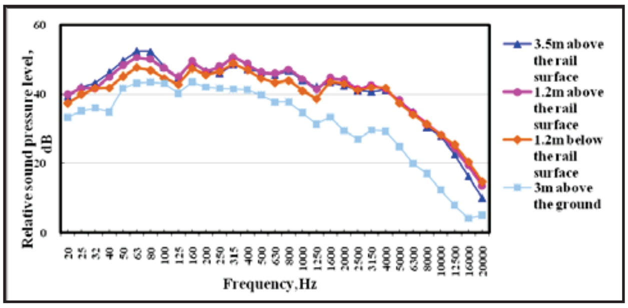

Figure6. Vertical distribution of noise frequency spectrum from bridge

Noise of medium-high frequency reduces quite obviously at the ground points, according to figure 6.

3.3. The horizontal distribution characteristics of noise from bridge

The test points were set 3m above the ground and have different distances (7.5m, 15m and 30m) from the track. (See Figure 7)

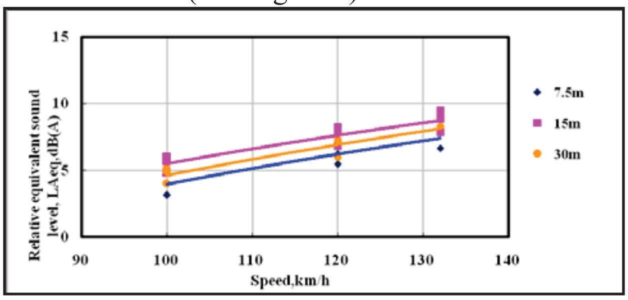

Figure7. Horizontal distribution of noise from bridge

The noise levels increase with increasing train speed. The distance of 7.5m from the track is in the sound shadow zone, noise level is lower than the noise of 15m by 1.1~1.7 dB(A). As the distance increases, the noise level at the distance of 15 from the track is higher than the noise of 30m by 0.8~1.2 dB(A).

4. Conclusions

We have tested for the radiation noise level and frequency spectrum in sections of bridge and subgrade on Lhasa –Shigatse Railway. The analyses of data show that when the train is running through subgrade section, noise level is slightly higher than the noise level in the bridge section; the vertical distribution characteristics of the noise from bridge show that the radiation noise on plateau railway is mainly caused by the noise in the wheel area; when testing points are at different distance from the ground, out of the shadow zone, the noise level decreases as the distance increases. The follow-up of the study is to simulate the noise propagation on plateau railway and start working on a modified noise equation consisted of special factors like air pressure on plateau railway.

References

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