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Environmental noise beside an elevated box girder bridge for urban rail transit

Key words: Urban rail transit; Elevated line; Environmental noise; Box girder bridge; Field measurement; Acoustic model; Doppler effect

Field Measurement: Description of Measurements

The aim of this paper is to provide a reference for the optimization of noise reduction of the rail viaduct at certain sensitive frequencies. The approach is combained experimental measurement and numerical simulation.

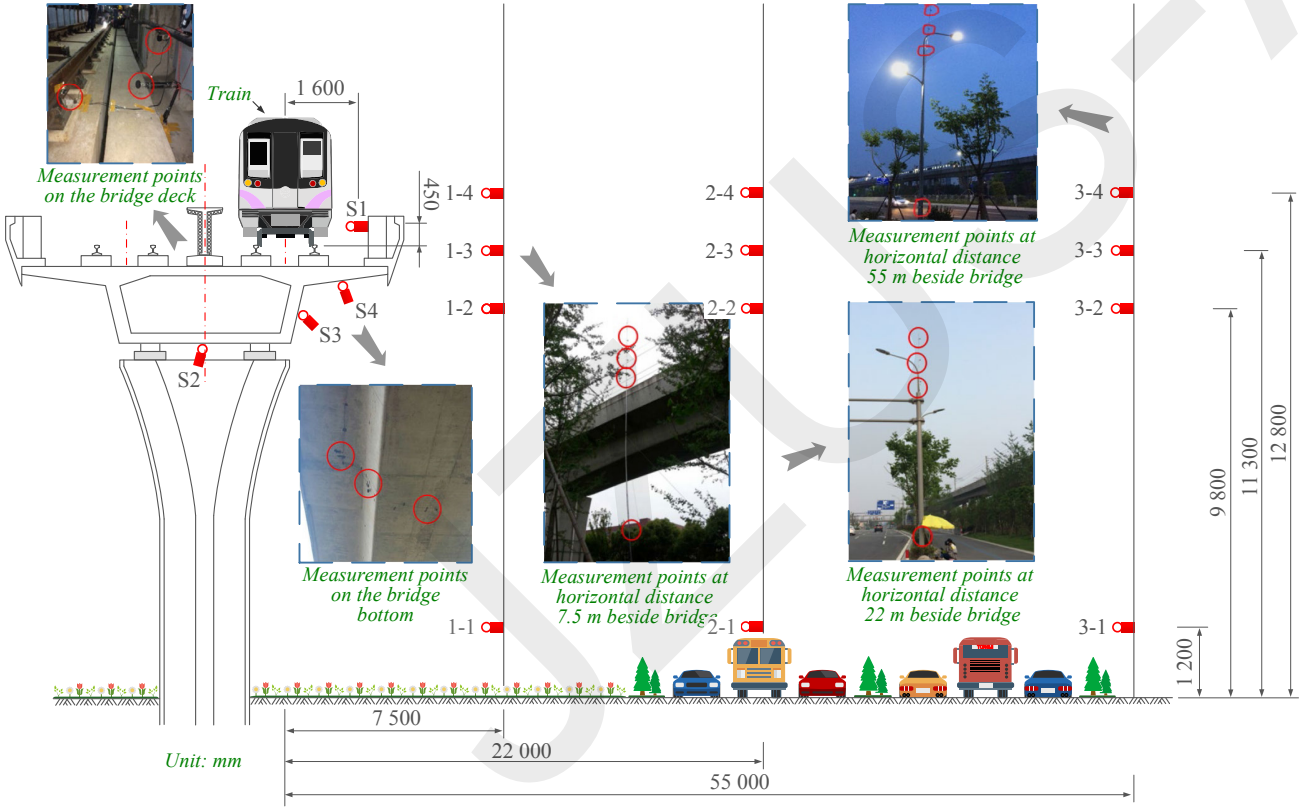


Fig.1 Layout diagram of noise measurement points

Table 1 Test conditions

Test conditions		
Ballast bed	Sound barrier	Location (m)
Ordinary	without	K4 + 825

Train speeds (km/h)	
Passing speed	Average speed
61.3 ~ 74.4	67.9

Field Measurement: Distribution of Environmental Noise

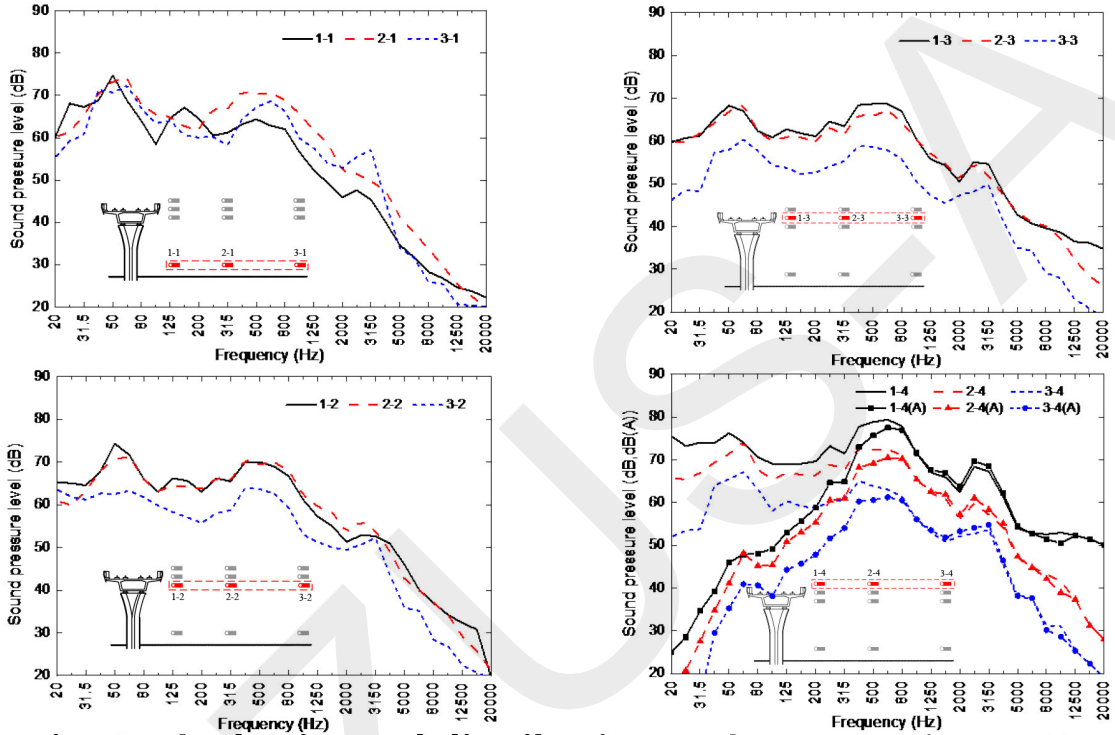


Fig. 2 The horizontal distribution and propagation pattern

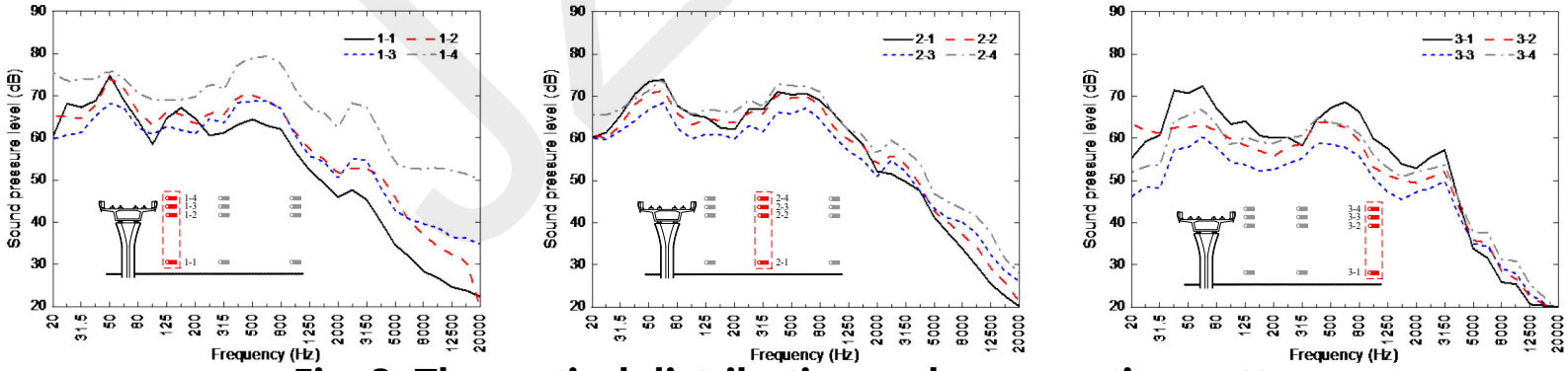
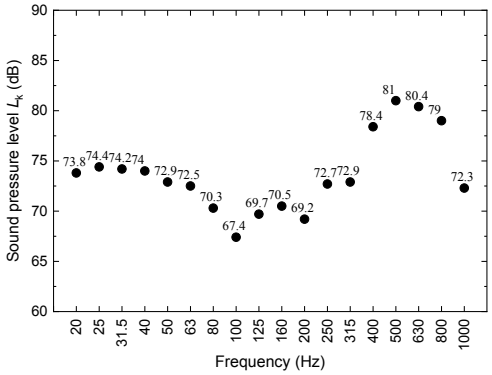
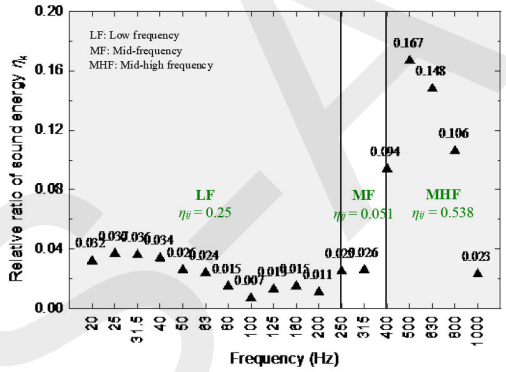


Fig. 3 The vertical distribution and propagation pattern

Field Measurement: Environmental Noise Energy



(a) Sound pressure level L_k



(b) Relative ratio of sound energy η_k

Fig. 4 The relative ratio of noise energy at point 1-4

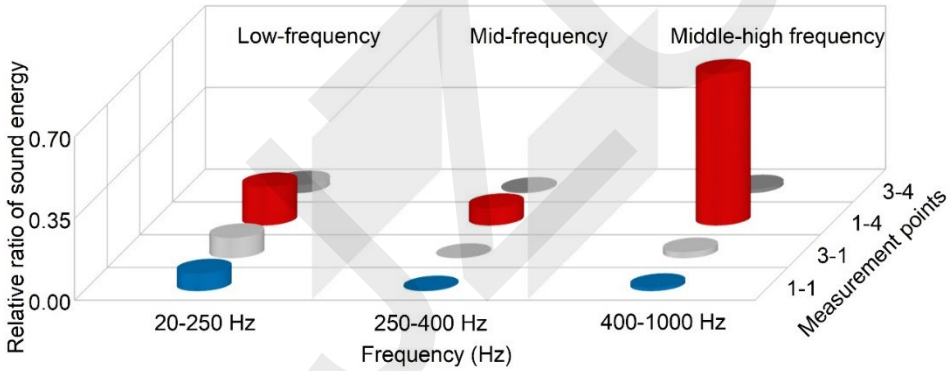


Fig. 5 The relative energy ratio of noise energy at measuring points on the bridge side in different frequency bands

The noise at measuring points 3-1 and 3-4 is largely dominated by low frequencies with energy account-ing for 8.85% and 3.2%, while in the mid-high fre-quency energy accounts for less than 3%.

Impact of Bridge Structure on Noise: Train-track-bridge Coupling Model

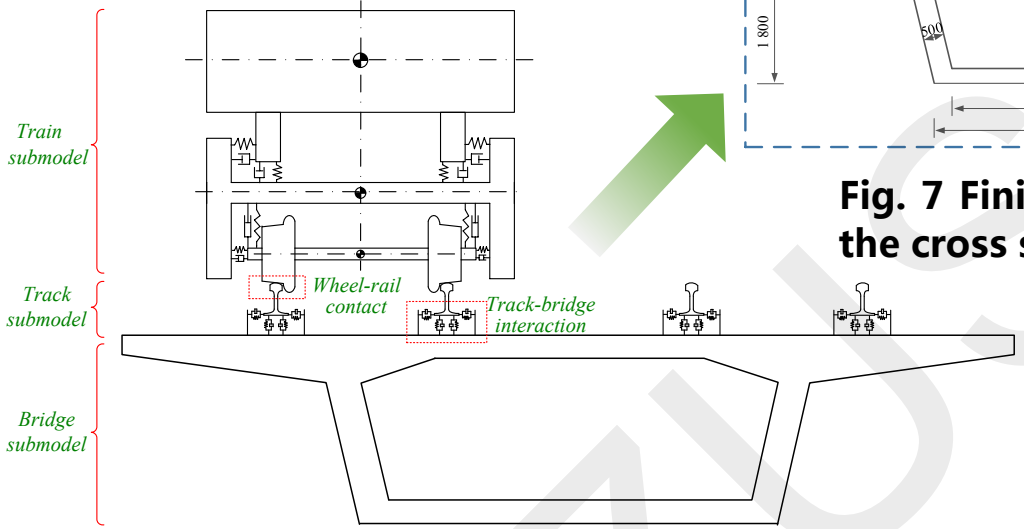


Fig. 6 Dynamic model of the vehicle-track-bridge system

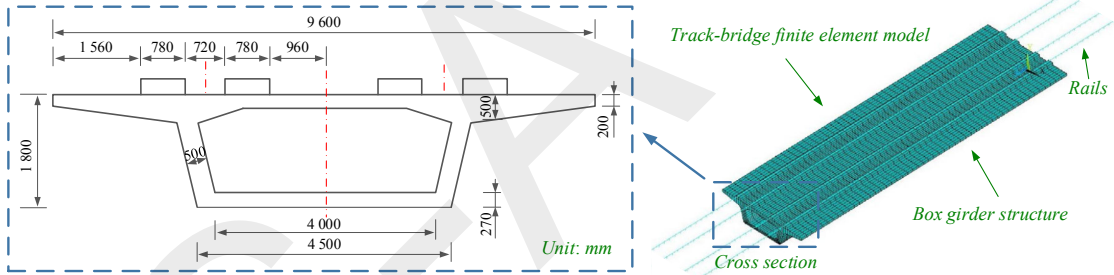


Fig. 7 Finite model and structural dimensions of the cross section of the bridge

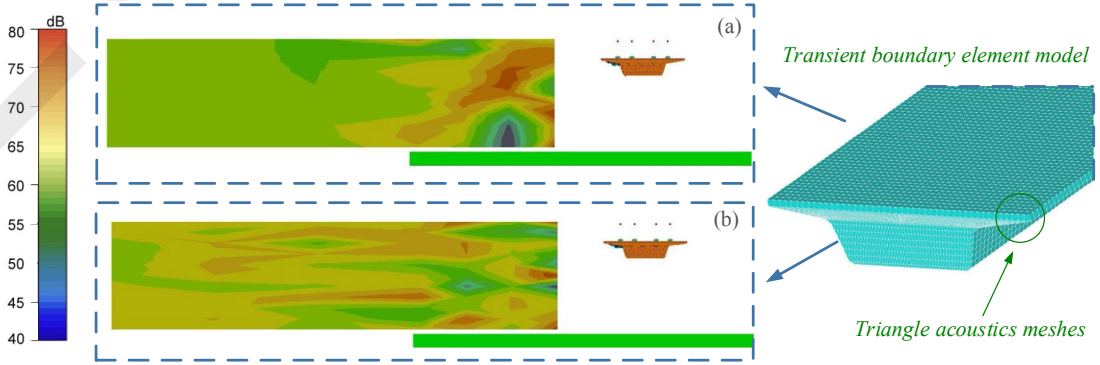


Fig. 8 Transient boundary element acoustic model and acoustic computing model

Impact of Bridge Structure on Noise: Acoustic Contribution of Girder Panels

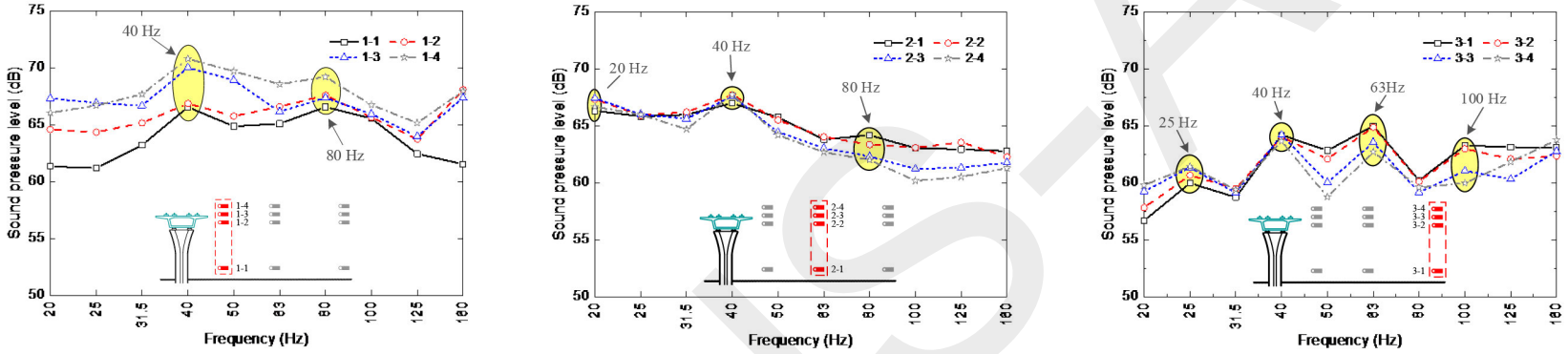


Fig. 9 The specific position of the bridge plate

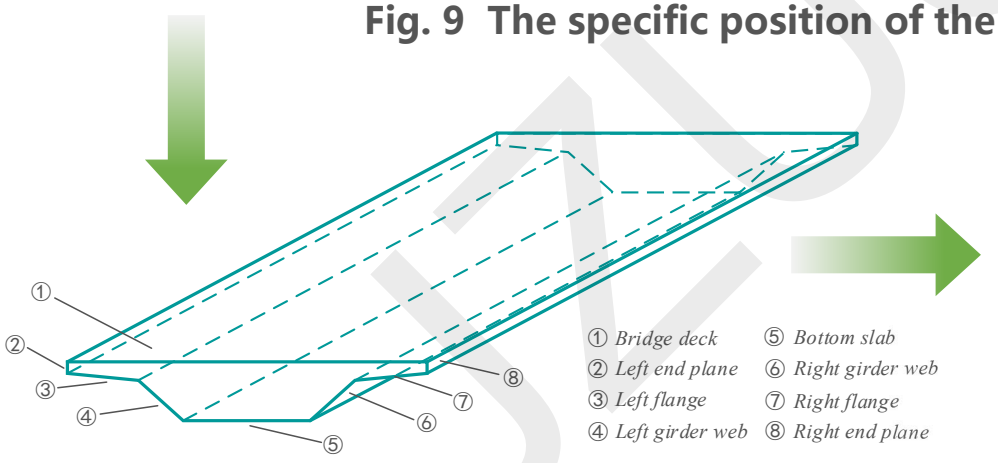


Fig. 10 The specific position of the bridge plate

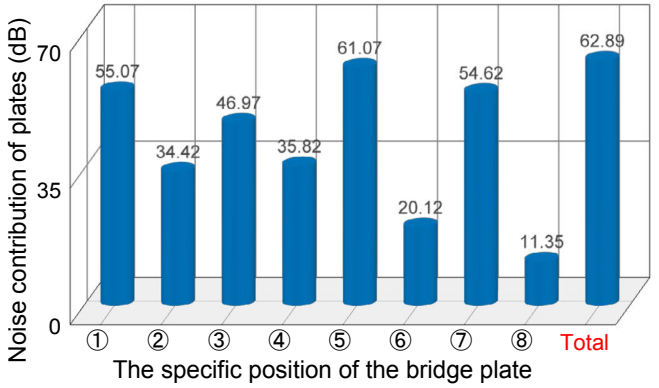


Fig. 11 Acoustic contribution of different bridge panels during train passage

Impact of Bridge Structure on Noise: Consideration of the Doppler Effect

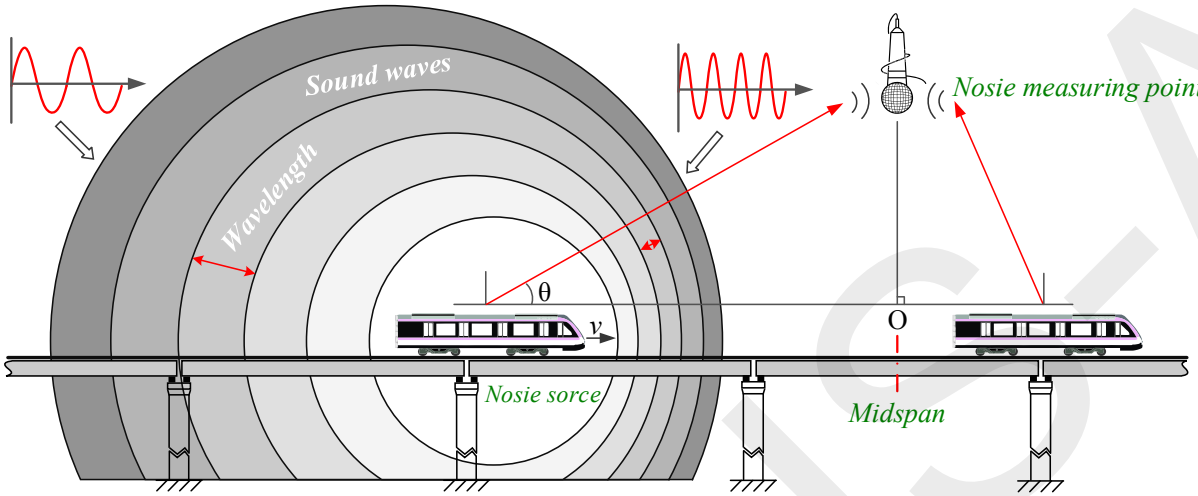


Fig. 12 The principle of the Doppler effect

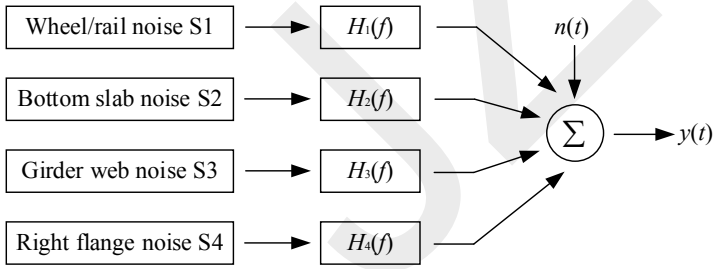


Fig. 13 Multiple-input and single-output noise model of the metro viaduct

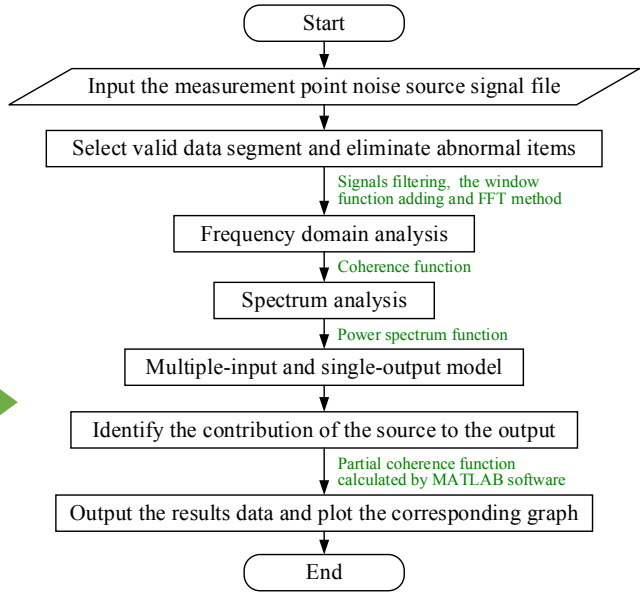


Fig. 14 Coherence analysis program

Impact of Bridge Structure on Noise: Coherence Analysis

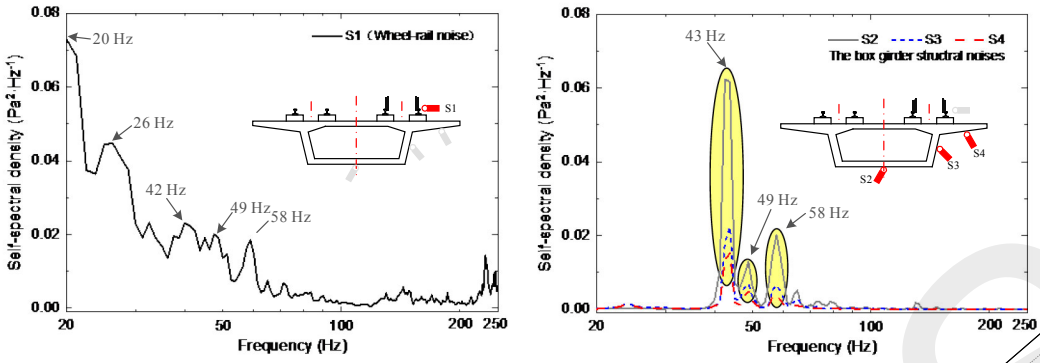


Fig. 15 Noise self-spectral density of the sensors installed

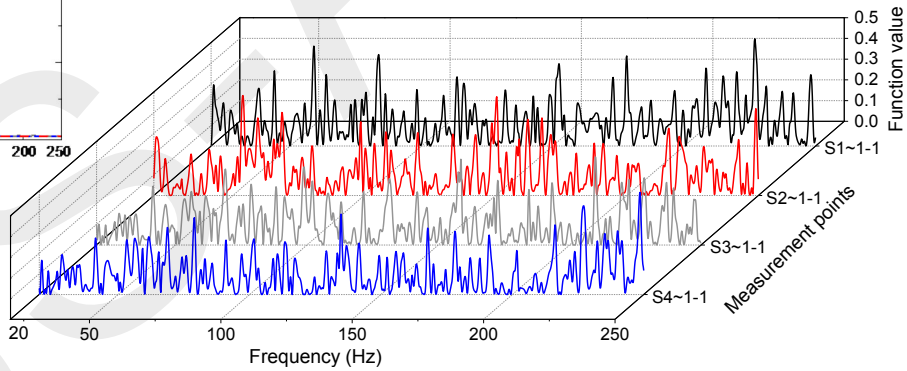


Fig. 16 Partial correlation function between noises on the viaduct and point 1-1 beside the viaduct

Table 2 The partial coherence function

	1-1			1-4			3-1			3-4		
	40Hz	50Hz	63Hz	40Hz	50Hz	63Hz	40Hz	50Hz	63Hz	40Hz	50Hz	63Hz
S1	0.121	0.082	0.355	0.303	0.289	0.338	0.165	0.203	0.088	0.105	0.272	0.221
S2	0.222	0.245	0.212	0.221	0.22	0.361	0.301	0.389	0.112	0.303	0.132	0.302
S3	0.284	0.089	0.178	0.161	0.265	0.221	0.23	0.254	0.122	0.161	0.307	0.233
S4	0.256	0.101	0.275	0.139	0.232	0.288	0.178	0.218	0.223	0.124	0.321	0.319
Main	S2,3,4	S2	S1	S1	S1,S3	S1,S2	S2	S2	S4	S2	S3,S4	S2,S4

Results and Conclusions

1. For environmental noise on the bridge side, the frequency band above 250 Hz is mainly affected by wheel/rail noise. The peak noise of the bridge is 31.5 to 63 Hz. The peak of wheel/rail noise is concentrated at 400-800 Hz. The noise intensity gradually decays from the near side of the bridge (low-frequency and middle-high-frequency energy is dominant) to the far side of the bridge (low-frequency energy is dominant) horizontally. It also decays in a vertical direction away from the noise sources. These patterns are influenced by the box girder structures.

2. The acoustic radiation calculation model based on the metro TTB model is effective. The Doppler effect plays an essential role in the measurement analysis, which has an influence of less than 6% on the frequency shift of an urban rail line with a speed of 67.9 km/h. The coherence analysis program performs well.

3. In the low-frequency band below 250 Hz, the main contribution to noise in the acoustic shadow area near the bridge and the ground is the vibration radiated noise of the bridge, of which the contribution of the bottom plate is the most prominent. In the vicinity of a strong noise source, in addition to wheel-rail noise, the contribution of the bridge bottom plate at 63 Hz is also large. The noise in the comprehensive noise area of the far bridge is mainly caused by the structure-borne noise of the bridge, and the largest contributors of panel radiated noise to environmental noise are the bottom slab and the bridge deck.