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The problem of high-speed railway noise prediction and reduction

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Abstract

In view of the rapid high-speed railway transport development in the world, the question of ecological safety of the people living in the areas adjacent to transport infrastructure networks, including physical factors compliance, becomes crucial. The article introduces problems of high-speed railway noise control and prediction (with train speed from 250 to 400 km\h), calculation methods for determining high-speed train noise characteristics; comparison of the calculation and experimental results is made. The article describes main ways of high-speed train noise reduction, in the noise source in particular, such as installing small local noise barriers and aerodynamic streamlining of the rolling stock and its separate elements (pantograph, etc.), implemented in China, Japan, France, German, South Korea and other countries. The article also considers efficiency of the main practically applied noise mitigation measures.

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Keywords: high-speed train, noise prediction, noise mitigation measures.

1. High-speed train noise regulation

High-speed trains, including magnetic levitation trains of the Maglev category, hold one of the leading positions in terms of convenience, safety and speed among all means of transport and even compete with planes. It's hard to imagine such countries as Japan, South Korea, China, France, Germany without high-speed railways that undertake a substantial part of the annual passenger traffic volume.

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However, along with developing of the transport links between cities and countries, it is necessary to control the environmental conditions which directly determine quality of living of the population. In order to solve this problem at the national level, noise regulation and assessment are conducted on intended for building and other land categories. It should also be noted that in many countries in addition to dividing the land into categories according to their properties (residential, industrial zone), there is extra gradation, for example, by degree of comfort in terms of the existing background noise levels. Rated parameters may also differ among themselves. In the US, for example, they depend directly on the functional properties of the land under consideration: either equivalent sound level (hereinafter - the SL) for the noisiest hour or daily equivalent sound level are estimated, including data for night and day periods [12].

Comparison of the maximum permissible sound levels acceptable on the territories of different states with references to the regulations is presented in Table 1.

Table 1. Noise requirements comparison.

Country/ Land category	Equivalent SL (*dBA*)		Maximum SL (*dBA)*		Reference to the regulating document
	day	night	day	night	
France	60	55	-	-	[25]
Italy/ Category 4 (intensive human activity zone)	65	55	-	-	Table C [10]
China/ Category 2	60	50			[13, 14]
Japan/ Residential areas	-	-	70		[34]
USA/ Land categories 1-2 with background sound level more than 77 dbA	65		-	-	[12]
Spain/ Residential areas	60	50	80	-	[30]
Germany/ Residential areas only	59	49	-	-	[31]
Russia/ Residential area	55	45	70	60	Table 3 [6]

As it is seen from Table 1, the requirements for acceptable noise levels in residential areas in different countries differ up to 10 dBA. Some of the strictest regulations are applied on the territory of the Russian Federation, which is connected with lack of more detailed system of categories separation in particular and lack of existing background noise levels records typical for certain areas and not changing significantly over the time.

Moreover, in many European Union countries the noise source type is taken into consideration while determining maximum permissible sound level. Thus, it is proved that at the same sound levels railway transport noise is less irritating than highway or airport noise according to Schultz curves [9].

Comparison of the L_{DEN} parameter conducted by the European Environment Agency for 14 states and published in 2010 visually represents the aforesaid [11].