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Procedia Engineering 189 (2017) 352 – 359

Procedia Engineering

www.elsevier.com/locate/procedia

Transportation Geotechnics and Geoecology, TGG 2017, 17-19 May 2017, Saint Petersburg, Russia

Reduction of vibroacoustic effect of high-speed trains

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Abstract

Increase of train speeds induces increased levels of vibration and structural noise in residential areas. The experimental plots were laid with different types of vibration isolation at the ballast base. It is shown that the polyurethane ballast mats are 1.9 times more effective than two layers of geocomposite and 1.5 times more effective than the porous rubber mats. Application of ballast mats significantly reduces vibration and noise in buildings near the railways.

Peer-review under responsibility of the scientific committee of the International conference on Transportation Geotechnics and Geoecology

Keywords: under ballast mats, damping, structure-borne noise, vibration

Introduction

High-speed train operation leads to increased dynamic vibration loads on tracks.

Negative impact of increased dynamic vibration takes the form of intensive accumulation of uneven permanent deformation of the ballast and the subgrade main surface, which is of particular concern for subgrades built of clay soils. It should be noted that more than a half of rail road subgrades in Russia have been filled with clay soils.

Another negative factor generated by dynamic action is noise and vibration occurring at the contact between wheels and rails. As a result, rolling noise is generated that contributes significantly to the train external noise.

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Peer-review under responsibility of the scientific committee of the International conference on Transportation Geotechnics and Geoecology
doi:10.1016/j.proeng.2017.05.056

Oscillations pass through the subgrade and propagating in the soil reach neighbouring buildings in the form of vibrations or so-called secondary structure-borne noise, which levels may be considerably higher than allowed ones. Vibrations transmitted via the soil to the structures are perceived as unpleasant low-frequency oscillations that affect physical well-being of people and precise instrumentation performance, or as disturbing noise.

Depending on their intensity and duration, noise and vibration have an adverse impact on the people living within affected areas. Therefore the high speed rail development programme of Russia provides for strict mitigation requirements to train negative impacts on tracks and the environment.

The studies of best vibration protection solutions for rails roads have been carried out for many years. At present there are the following vibration damping methods for rail track structures:

- Damping elements for rail joints;
- Elastic pads under sleepers;
- Under ballast vibration protection materials.

Whereas the first two methods are well studied both in Russia and abroad, under ballast vibration protection materials require comprehensive research in terms of operation conditions of the Russian rail roads. This paper describes the results of tests carried out using the most common types of under ballast mats.

1. Vibration and noise impact from trains

The main noise sources of trains are rolling noise, locomotive noise and aerodynamic noise. At speed of 60 to 300 km/h, rolling noise is dominant, i.e. rolling noise contributes the most to the overall noise of high-speed trains [1].

Rolling noise level is determined by the following parameters (Fig.1):

- Roughness of the wheel and the rail that influences the wavelength;
- Wheel-rail interaction

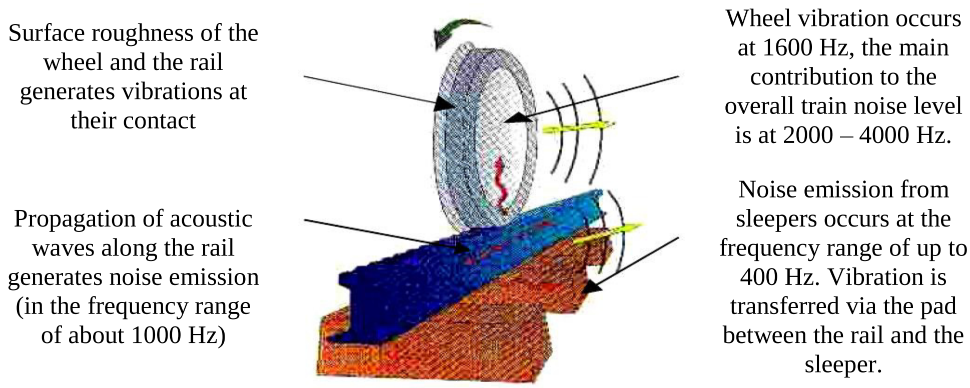

Fig.1. Physical mechanism of the rolling noise generation.

The process of the rolling noise generation is described by the model developed by Remington. The graphical scheme of the model is shown in Fig. 2 [2].

Excitation forces generated at the contact depend not only on the roughness but also on the car axle loads, train speed and wheel-rail contact area. These forces are associated with the mechanical impedance of the wheel and the rail and are predetermined by their design.

At the area of the wheel and rail interaction, a so-called contact spot appears. The contact spot includes an intermediate layer that is a mixture of iron oxide and wear products of the wheel and the rail. This mixture acts as a kind of the pad that reduces occurring forces and plays the role of a filter. The vibration occurring at the interaction of excitation forces excites