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Static and dynamic characteristics of resilient mats for vibration isolation of railway tracks

Cezary Kraśkiewicz[a], Cezary Lipko[b], Monika Płudowska[a]*,

WojciechOleksiewicz[a], Artur Zbiciak[a]

[a]Warsaw University of Technology, Faculty of Civil Engineering, Institute of Roads and Bridges, 16 Armii Ludowej Ave., 00-637 Warsaw,
[b]TINES Capital Group SA, TINES Railway, Ciepłownicza 23 Street, 31-574 Cracow

Abstract

The paper presents essential static and dynamic properties characterizing resilient mats for vibration isolation of railway tracks. The attention was focused on under-ballast mats and slab-track mats used in the construction of railways. Referring to this type of mats, selected test procedures for determining the values of parameters describing static and dynamic characteristics were described. Basic classification of vibration isolation mats was presented in the paper. Moreover, the essential functional and operation features related to various types of mats were given. Some theoretical aspects concerning viscoelastic dynamic modelling of resilient track elements were also outlined. In order to characterize requirements and methodology of research for resilient mats in railway tracks, German Standards [1-3] were used herein.

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Keywords: railway construction; vibro-acoustic issolators; vibration reduction; under-ballast mats; slab-track mats; structural vibrations

* Corresponding author. Tel.:+ 48-22-234-1536.
E-mail address: m.pludowska@il.pw.edu.pl

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1. Resilient mats in railway tracks

Resilient mats in railways are used for vibration isolation of railway track by reducing dynamic effects of rail traffic. The reduction relates mainly to vertical and transverse material vibration, but also to structure-borne noise.

Under-ballast mats are used in the track superstructure on engineering structures such as bridges, track troughs and tunnels. They increase resilience between the ballast and the track, and reduce vibrations emitted into the environment.

In ballast-less track system resilient mats have similar purpose as under ballast mats. Nonetheless, a ballast-less track system is always an individual engineering solution for a particular application. In particular, in a slab track system resilient mats are applied horizontally and vertically directly below and from the sides of the concrete track base plate. The resulting floating slab track system is effective in mitigating vibrations, especially in low frequencies. It also can achieve a significant reduction in vibrations and structure-borne noise emissions at excitation frequencies above $\sqrt{2}$ times the tuning frequency.

Resilient mats can be grouped into two categories, because of the range of applications in various types of railways track construction:

- Under-Ballast Mats (UBM)/ Sub-Ballast Mats (SBM) or ger. *Unterschottermatten* (USM) – used in ballast railway track;
- Slab-Track Mats (STM) – used in ballast-less railway track.
- Under-Ballast Mats have two varieties with regard to the main purpose of their use:
  - used primarily for isolation from vibration,
  - used primarily for stress reduction in ballast.
- Slab-Track Mats have three varieties with regard to the slab support system:
  - elastomeric pads (discrete support),
  - strip mats (linear support),
  - elastomeric mats (continuous support).

Due to materials used and production technologies, resilient mats can be grouped into mats made of various kinds of elastomers (elastomeric mats) or mineral wool mats. Elastomeric mats can be divided into two groups:

- mats based on polyurethane in versions with closed or open pores;
- rubber mats (composites based on blends of natural rubber and / or synthetic rubber), which resiliency is ensured by shape (channels, grooves or protrusions of different shape) and cross-sectional structure of the mat (density and pore volume).

Resilient mats can have an uniform structure (homogeneous) or a layered structure (with layers of different materials and features).

2. Functional properties of resilient mats

Technical characteristics of resilient mats relates to technical and functional properties of materials, which are the most relevant for fulfillment of its essential functions, such as:

- effective vibration isolation - maximum reduction in the level of impact in form of vibration and structure-borne noise;
- increased technical lifespan - maintaining long-term ability to fulfill functions mentioned above in real operating conditions, with maximum 20% of variability of main parameters of the states during laboratory fatigue tests conducted under extreme operating conditions.

Given the above requirements, the most important parameters for assessing the quality of resilient track mat can be determined due to the function (vibration isolation, working life, material characteristics in accordance with the specifics of operating conditions). In case of vibration isolation it is:

- static and dynamic vertical stiffness ($k_{stat,z}$, $k_{dyn,z}$), static and dynamic vertical ($C_{stat,z}$, $C_{dyn,z}$) bedding modulus,
- horizontal static stiffness ($k_{stat,h}$) and horizontal static bedding modulus ($C_{stat,h}$),
- loss factor η defined by the ratio of energy dissipated to energy expended.

The last coefficient is related to, important for the damping characteristic of the elastomer, dynamic stiffening ratio. By working life (fitness) of resilient mat is meant mechanical fatigue strength including changes of vertical