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Calculation methods and technological applications creating sustainable railway tracks satisfying the modern operational demands

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Abstract

The most important step in the calculation and dimensioning of railways superstructures is determination of proper rail types, fastening and supporting systems ensuring an integrated track system with long service life and as much as possible low construction costs. Without proper maintenance of the railway track it is impossible to ensure sustainable railway superstructure. Providing the elasticity of the rail tracks is also a special challenge for the railway engineers because these days the decreasing of noise pollution and vibrations play a main condition in sustainable rail track design.

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Keywords: dynamic factor; analitycal calculations; numerical calculations; elastic pads.

1. Introduction

First concrete sleepers were made of normal reinforced concrete in 1930s and used until the World War II. Concrete railroad ties became popular in Europe after 1950s because of the advances ensured by the pre-tensioning and later by the post-tensioning process.

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Now as before, worldwide concrete sleepers represents the main rail support systems in the rail superstructures. During the last decades appeared many types of these elements like: mono block sleepers, twin block sleepers, frames sleepers.

The continuously increasing operational loads and speeds forced the railway companies to develop their technical and economical system to keep their vital role in transporting passengers and merchandise. This step meant the formation of high speed railways. [1, 2]

This modernization process led to appearing of the ballastless (slab) track systems in the middle of 1960s. The first country which recognized the need of replacing of ballasted track systems to slab track systems in case of high speed railways was Japan. It was followed later by Germany, Italy, Spain.

The SNCF, the French national railway company is an interesting exception with regards to the track superstructures. The rail supports used by the SNCF on the high speed rail tracks, operated by the TGV, are twin block sleepers in ballasted bed. This example also shows clearly that, both rail systems are really important, and mainly economical questions decide which one is worth to use.

2. Analytical calculations

Dimensioning and study of elements of railways` superstructures is already a very old process, it had begun simultaneously with the appearance of the railway. Initially the engineers designed the railways structures by completely relying on previous experiences and practices but over the time many other methods had been developed for the calculation of railways superstructures [2].

Current practices in the world concerning the calculation of railway structure are mainly based on the method of Zimmermann – Eisenmann “beam on elastic foundation”.

This is a wieldy used calculation method in the world, which was determined, taking into account the dispersion of measured values on rail tracks with different conditions. It is useable at the design of ballasted and slab track superstructures.

It is a suitable method for calculation of dynamic influences caused by the rail traffic taking into account the elasticity and conditions of superstructures.

The European standards determine the dynamic influences of rail traffic only in case of bridges (EN 1990 / A1 and EN 1991 – 2 - 2004). But the design loads calculated with these factors are mostly different than the loads achieved with using the factors calculated with the Zimmermann – Eisenmann method.

$$Z_{din} = Z_{stat} \cdot \beta \tag{1}$$

$$\beta = (1 + t \cdot s) \tag{2}$$

$$s = \alpha \cdot \varphi \tag{3}$$

Z_{din} – dynamic wheel load, [kN];
Z_{stat} – static wheel load, [kN];
β – dynamic amplification factor;
t – multiplication factor of standard deviation which depends on the confidence interval. Since the rail is so important for safety and reliability of rail traffic a value of 3 is recommended as the chance of exceeding the maximum calculated stresses is only 0.15 %;
α – factor depending on track quality;
φ – factor depending on train speed;

3. Numerical calculations

Numerical analyses can be carried out by finite element programs. Since the rail track support elements like the concrete sleepers or concrete slabs are manufactured mostly using the pre-tensioning or post-tensioning methods,