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Jaroslav SMUTNÝ*, Luboš PAZDERA**, Otto PLÁŠEK***

STRESS ANALYSIS IN THE RAILWAY SUBSTRUCTURE

ANALÝZA NAPĚTÍ V PRAŽCOVÉM PODLOŽÍ ŽELEZNIČNÍ TRATĚ

Abstract

The paper is focused on the stress measurement in the railway substructure in the turnout prototype designed for a high speed. The aim of the measurement and its evaluation was to compare the results obtained with theoretical presumptions. The methods of the measurement and its evaluation are described. The conclusions of the stress in the railway substructure included its relation with the train speed. It may also be stated that the quality elaboration of the measurement considerably contributed to modern means of the signal analysis.

Abstrakt

Příspěvek se zamřuje na měření tlaku v železničním spodku pod výhybkou, která je navržena pro pojezd velkou rychlostí. Cílem měření a jeho vyhodnocení bylo porovnat získané výsledky s teoretickými předpoklady. Popsán je způsob měření a vyhodnocení. Tlak v železničním podloží má vztah k rychlosti vlaku. Ke kvalitě podrobného vyhodnocení měření značně přispívá moderní způsob analýzy signálů.

1 INTRODUCTION

The railway substructure is one of the fundamental components of the railway line. By the railway substructure we understand the railway substructure body, the structures of the railway substructure, traffic areas and communications and small structures and the railway substructure equipment. From the viewpoint of the load transmission by railway carriages to the railway formation, the railway structure is divided into two basic components: the flat framework made up of rails and sleepers and the structure that consists of ballast bed, structure layers and formation. The upper surface of the roadbed is formed by the ballast bed. The construction of the railway substructure must be such to permanently secure the prescribed geometrical position and to secure the transmission of both the static and dynamic loads by railway carriages without a permanent deformation of the track bed [2].

It is evident that especially the construction layers of the railway substructure and the soil under the track bed are decisive for damping dynamic effects. The spreading of the dynamic effects in the railway bed is damped to a small extent only, most of the energy is transferred lower [1, 2].

* Ass. Prof. Ph.D., Department of Railway Construction and Structures, Faculty of Civil Engineering, Brno University of Technology, Veveří 95, Brno, Czech, tel. (+420) 54114 7322, e-mail Smutny.J@fce.vutbr.cz

** Ass. Prof. Ph.D., Department of Physics, Faculty of Civil Engineering, Brno University of Technology, Veveří 95, Brno, Czech, tel. (+420) 54114 7657, e-mail Pazdera.L@fce.vutbr.cz

*** Ass. Prof. Ph.D., Department of Railway Construction and Structures, Faculty of Civil Engineering, Brno University of Technology, Veveří 95, Brno, Czech, tel. (+420) 54114 7657, e-mail Plasek.O@fce.vutbr.cz

2 MEASUREMENT SET-UP

The subject of the measurement was the stress measurement in the construction of the railway substructure in the turnout in the railway station (Fig. 1), provided with a movable frog. The rails are fixed to concrete sleepers by means of a flexible fastening of the Vossloh type. In the switch part of turnout there are two trough sleepers, in the common crossing there is one trough flange type sleeper.

Fig. 1 Tested railway substructure with turnout

To the measure of the normal stress, special pressure sensors (Fig. 2) inserted in the railway substructure during the construction operations was used. The sensors were placed in the turnout exchange part and under the movable frog. At each observed point, two sensors were placed – the first one on the formation, the other one immediately under the ballast bed. The measurement utilised plate sensors of the series 3500 made by the firm GEOKON (Fig. 2).

Fig. 2 Pressure sensor placed into railway substructure

The apparatus PULSE made by the firm Bruel&Kjaer was used. The apparatus was provided with four memory channels. The records were stored in the measuring computer. The train speed was monitored by means of two strain gauge sensors placed on the bases of the rails [1]. The strain gauge sensors were placed in the middle and in the frog parts of the turnout. The strain gauge sensors formed an 18 m long basis.

The normal stress at the selected measuring points was measured for trains running at the speed from 70 km·h^{-1} to 160 km·h^{-1}. [1]

2 EVALUATION OF MEASUREMENT

Having analysed the check measurement and the calculations, the following methods and parameters were used for the evaluation of the signals measured:

1. Time display of the course of normal stresses at particular measuring points, the evaluation of extreme stress values
2. Descriptive statistics
3. Estimates of mean values (t-test) and scattering (F-test), the tests were carried out at the significance level $\alpha = 5\%$
4. To determine the measure of interdependence of the highest stress values for the train passage, the correlation coefficients for particular groups of trains were calculated
5. Time-frequency spectral analysis (for the transition from the time to time-frequency area the algorithm of Rihaczek transformation was used)

The mathematical definition of the time frequency transformation Rihaczek is given by the following relation [2]

$$RT(n,k) = x(n) \cdot X[k] \cdot e^{-\frac{j \cdot 2 \cdot \pi \cdot n \cdot k}{N}}, \qquad (1)$$

where N is the number of samples, $n = 1, 2, \ldots, N$ is the time step multiplicand, $k = 0, 1, 2, \ldots, M$ is the frequency step multiplicand, $X[k]$ represents Fourier´s sequence transformation $x(n)$, and $RT(n, k)$ is the time frequency representation of sequence representing a discrete signal. [2]

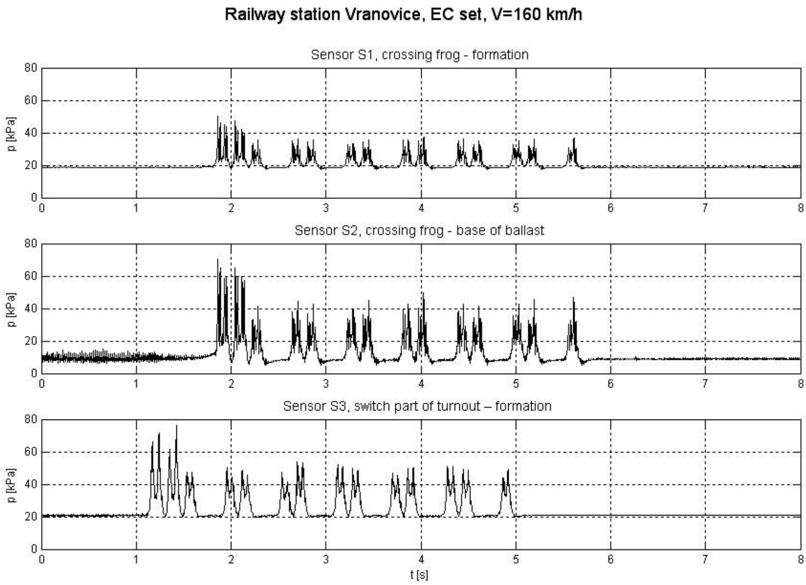

Fig. 3 Stress signals for the passage of the set of carriages of the train EC, speed 160 km.h^{-1}

Fig. 3 shows stress signals for the passage of the set of carriages of the train EC, speed 160 km.h^{-1}. Fig. 4 shows a signal analysis for sensor S1 of the record from Fig. 3. The upper graph of this figure represents the original time record, the middle graph shows Rihaczek transformation and left graph shows frequency analysis by Fourier transformation.

3 CONCLUSIONS

In general, we may say that the ascertained values of the normal stress correspond with the theoretical assumptions. Although the stress was measured in dynamically exposed places of the turnout structure, it did not excessively exceed the values expected for a common rail. For this reason, it may be stated that the structural alterations in the turnout represent a clear contribution as regards the sleeper subgrade.

The stress values on the track bed and on the subgrade in the absolute value do not exceed the value of 90 kPa, on the subgrade these correspond to the expected stress up to 100 kPa

The stress in the railway substructure only slightly depends on the train speed. The measured normal stress also slightly increases with the increasing train speed.

The ascertained stress dynamic component under the frog point on the subgrade is considerably higher than that under the switch part and forms a substantial component of the load. Mean values of the extreme stress at the train passage did not statistically change in both stages of the measurement. A slight decrease of the largest stress was proved under the change part.

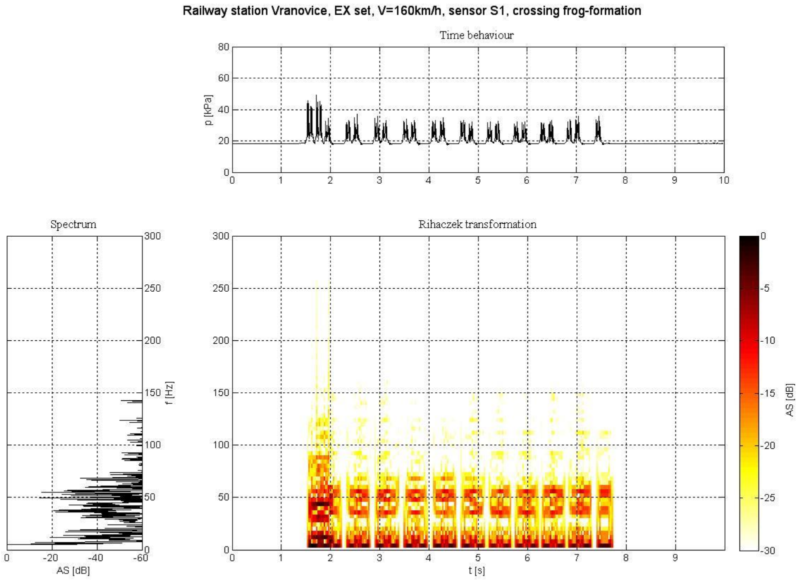

Fig. 4 Time frequency analysis for the passage of the set of carriages of the train EC

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Reviewer: Ing. Karel FRYDRÝŠEK, Ph.D., ING-PAED IGIP, VŠB-TU Ostrava