SCIENTIFIC PAPERS
OF THE UNIVERSITY OF PARDUBICE
Series B
The Jan Perner Transport Faculty
18 (2012)

ANALYSIS OF BEHAVIOR OF RAILWAYS TRACK SUBSTRUCTURE

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1.INTRODUCTION

This paper deals with the experimental measurements of pressures in the substructure of railway track. It described the design of sensors that have been developed at the Department of Transport Structures, Jan Perner Transport Faculty of the University of Pardubice; the imposition of these sensors to the measuring site and outline the results of this measurement

2.DESCRIPTION OF THE MEASURED SPOT

Mounting tensometric indicators on the railway line Pardubice (main station) – Jaroměř was carried out in cooperation with Railway Transport Administration and Chládek a Tintěra company, Pardubice a. s. in November 2010. Place which was chosen for floor pressure analysis lies nearly 574 m far from the dispatching building of Stéblová railway station in the direction Pardubice – Rosice nad Labem on an electrified rail. Superstructure here consists of a contactless track and a rail of shape R65 fixed to concrete sleepers SB 8P by means of an assembly sort K. Detailed description with a technical specification is to be found in the chart n. 1.

Chart 1 *Technical specification*

Railway line	Pardubice hl. n. - Jaroměř (TTP) 505c
TUDU (number of the track section, the definition section)	1612B1
The stationing [km]	9,032
Class trackside load	D4
Order Railway	4
Railway speed [km/h]	100
Directional and height ratios	direct
Station track	number 1, main rail
Traction lines	3 kV DC

On the basis of carried out numerical analysis the pressure indicators were placed into the substructure body in three vertical levels and altogether 5 indicators were placed in each level. Considering the fact that these indicators were put into one section, it is possible to monitor the process of load transfer from train transport to the earth body. In the third layer of vertical level -1,085 m under the bottom loading area of the sleeper, the indicators S12, S11, S1, S20 a S15 were laid. Each indicator was fixed into a bed and covered up with siliceous sand PR30/31. Everything was made according to the rule of geometric analogy of a model and reality, where in the spot of an indicator there must be the same conditions as during laboratory calibration of used indicators. After fixing all the five indicators into the profile there followed ground bashing by means of a vibratory rammer NTC NT – 65 and a vibratory roller Stavostroj VVW 3400. The second layer of indicators S2, S7, S10, S3, S13 lies in the hight of 0,8 m and the first layer of indicators S16, S9, S17, S5, S14 lies in the hight of 0,39 m under the loading area of a sleeper. All the shielded cables were protected against machanical damage by protective pipes Kopoflex 40. Detailed description of pressure indicators placement is shown in the following picture.

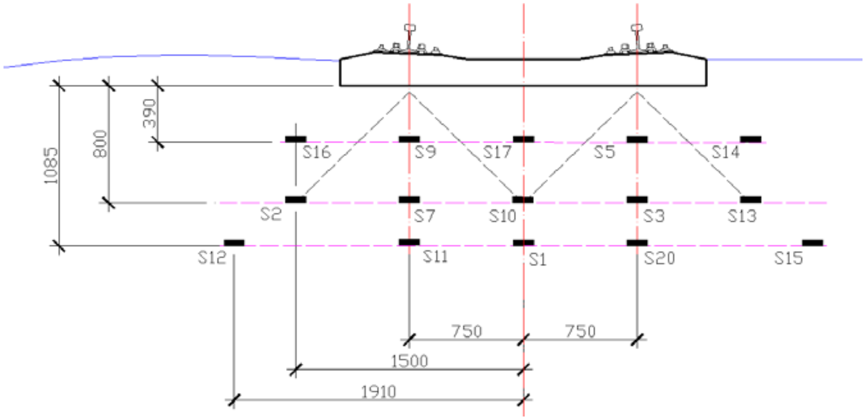

Fig. 1 *Detailed description of pressure indicators placement*

Fig. 2 *The deployment of sensors, layer II*

3.DESCRIPTION OF THE MEASURED SPOT

Pressure tensometric indicators consist of two parts. Bottom and top parts of the indicator were made of stainless round steel Ø 80 mm. After turning out the exact shape of the indicator, threads for screws were drilled and carved in the border. They enabled creating a firm joint of bottom and top part of the indicator into one unit. In the joint of both areas there is a gasket that hermetically seals the indicator. Geometry of the indicator and basic dimensions are shown in the figure n. 1 and n. 2. In the inside area of the indicator there were stuck tensometres of type 6/120LY11 with a linear grid, carrier – polyamide, grid – constantan, grid resistance 120 Ω. For attaching tensometre on stainless parts of the indicator, cyanoacrylate glue Z70 was used (low hysteresis order of points from the total measured deformation value). Indicator instability from the point of view of temperature influence is eliminated by compensatory tensometres. There are two active tensometres in one indicator, first on the bottom part and the second on the top part of the indicator and two compensatory tensometres, each of them thermally compensates one active tensometre. Outlets of tensometres into the measuring chain were connected on a terminal block by soldering with a soft solder. Tensometre connection in the indicator is made as a full Wheatston bridge. Interconnection between indicators and a logger is realized by means of six-core shielded cables of type P1-CABA1/100. All the active parts are protected by silicone rubber.

Strain gage dimensions, steel, 6/120LY11

- the temperature response α= 10.8 [10^{-6}/°C]
- the temperature coefficient 93 ± 10 [10^{-6}/°C]
- nominal rezistance 120 Ω ± 0,35 %
- k- factor 2,08 ± 1,0 %
- dimensions [mm] a: 6, b: 2,7, c: 3, d: 6

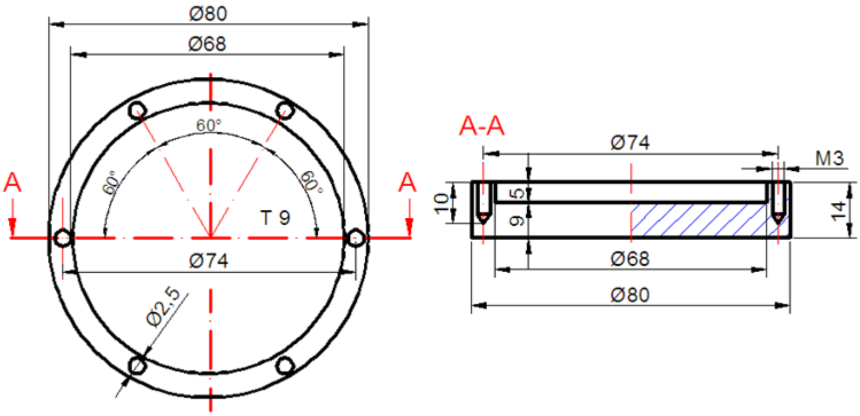

Fig. 3 *Pressure tensometric indicators*

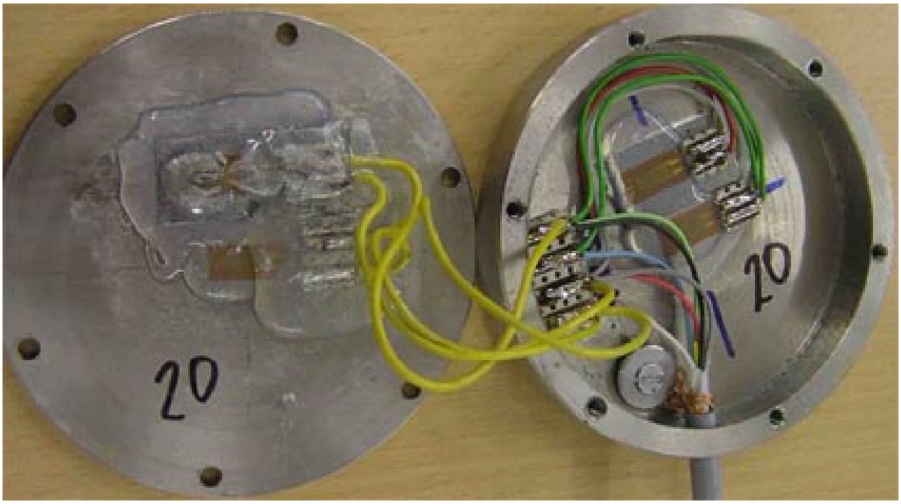

Fig. 4 *Pressure tensometric indicators*

For the evaluation of a response from tensometric indicators is used a dynamic logger from the company Hottinger Baldwin Mestechnik of the type DMC Plus. The logger contains on the whole 20 measuring channels which are parallelly connected through a busbar with the central processing unit. It is possible to select measuring speed up to 9600 scanned values per second. Input data are passed into the inside busbars of the device where they can be digitally filtred, linearized or processed by mathematical function. Digital filtres can be switched off or set up for the mode of floating or arithmetic average, exponential filter or rounding. Maximum accuracy of measurement is 20 bits. If it is not possible to transfer measured data from the device in on-line mode, we can record them into data memory with the capacity of 500 000 measured values. Signal scanned by the logger was processed in the program BEAM-DMC made by AMS producer. For interconnection with PC there was used standard interface RS-232 or RS-485.

4.LABORATORY CALIBRATION OF INDICATORS

Each tensometric indicator was calibrated in the laboratory of The Highway Construction Department before fixing into measured profile. Deformational sensitivity dependence was determined for every indicator with statistic check. All the process of calibration was carried out by gradual loading of indicators in several cycles. At the beginning of the whole calibration process the tensometres were zeroed and relevant resistance values were set up. Calibration itself ran for each loading state separately and it was possible to observe the loading progress directly on tensometre outputs. For calibration it was used a steel cylinder of 400 mm diameter and 800 mm hight with a firm bottom, where there was developed necessary power on solid top board of the calibration container through a compound lever.

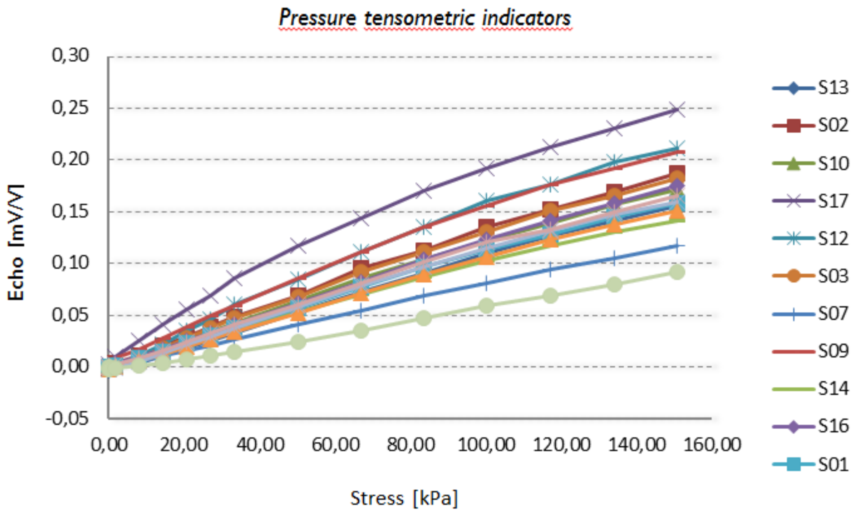

Fig. 5 *Pressure tensometric indicators*

This board developed necessary pressure on the indicator, which was laid into siliceous sand PR30/31 with exactly defined granulation curve. The indicator was laid in half hight of the cylindrical container, which is 400 mm from the bottom. Desired changes of pressure were determined from the change of resistances by given values from calibrating curves of individual indicators.

5.RESULTS OF MEASUREMENT

Tensometric measurement of pressures was running in regular intervals on the basis of elaborated measuring method. Individual cabels from indicators are permanently laid in a shaft which lies about 8 metres from the track axis. During a preparation of measuring itself it was necessary just to gauge indicators with cables and to treat connectors against corrosion. After connecting individual connectors to the logger, parameters of indicators were set up on the basis of carried out calibration. For the successful process of measuring itself it was necessary to ensure failure-free function of all elements of the measuring chain including measurands indication also from the point of view of chosen way of measuring results processing. Measuring chain is composed of a tensometric pressure indicator, a logger (A/D converter), a personal computer for recording and processing measured data. Sampling frequency was chosen 150 Hz with the use of a manual recording start with recording length 180 seconds. In the selected spot of measurement there were scanned transits of fast trains, passenger trains and also express trains.

Evaluation of the response of pressure tensometric indicators was carried out for composition of propulsive and tractional vehicles which run regularly on the railway line Pardubice (main station) – Jaroměř.

Types of measured traction vehicles:

- series 163 [ČD]
  - manufacturer: Škoda Plzeň
  - operator: České dráhy, a.s.

Types of measured towed vehicles:

- series Bdmtee[281] [ČD]
  - manufacturer: VEB Waggonbau Bautzen
  - operator: České dráhy, a.s.

From the results of pressures recorded on the indicators it is possible to define an interval of resulting measured values which are summarised in the chart n. 2. Dispersions of measured pressure values on the indicators in individual layers of substructure body are necessary to attribute to different speeds of sets of wagons during their passing through the measured spot and also to technical states of vehicles and also to the quality of substructure and superstructure.

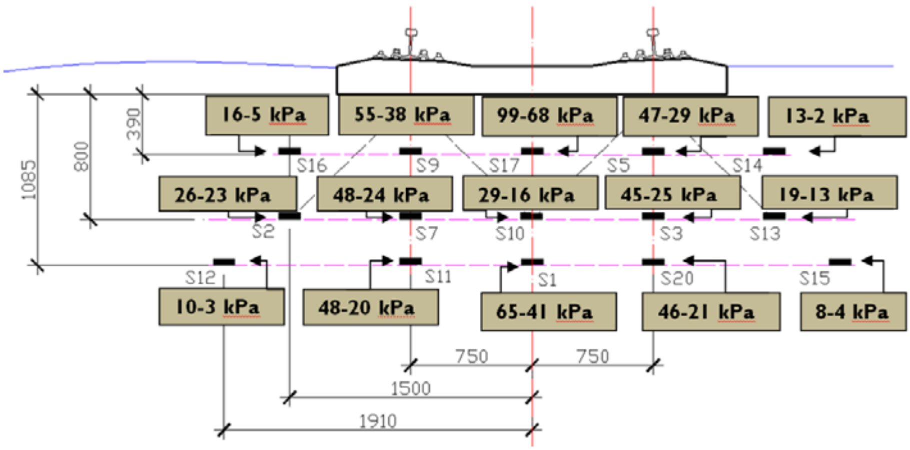

Fig. 6 *The results tensometric measurement of pressures*

Chart 1 *Resulting measured values*

tensometric indicators	*maximum [kPa]*	*minimum [kPa]*	*mean value [kPa]*	*standard deviation [kPa]*	*median [kPa]*
S01	**65,07**	**41,28**	56,94	8,62	56,42
S02	**26,24**	**23,66**	24,52	1,49	23,66
S03	**45,93**	**25,42**	37,50	8,44	42,01
S05	**47,99**	**29,44**	41,36	6,66	43,78
S07	**48,38**	**24,88**	39,97	8,09	43,64
S09	**55,85**	**38,79**	47,26	6,59	47,74
S10	**29,79**	**16,78**	22,79	4,99	23,93
S11	**48,87**	**20,78**	39,41	9,95	43,01
S12	**10,35**	**3,30**	6,80	2,27	6,46
S13	**19,09**	**13,12**	15,57	2,50	15,52
S14	**13,90**	**2,62**	8,41	4,00	6,37
S15	**8,02**	**4,46**	6,59	1,25	6,80
S16	**16,38**	**5,40**	8,52	4,52	6,06
S17	**99,82**	**67,88**	83,86	11,20	82,47
S20	**46,72**	**21,20**	37,83	8,25	39,80

6.CONCLUSION

Measured data will be a base for creating another measuring spot in cooperation with SŽDC, s. o., probably in station parent tracks or main tracks on the railway line between Pardubice and Česká Třebová. This spot will be selected with the goal to monitor pressures in a sleeper bed also at higher speeds of passing vehicles than so far (that is higher than 100 km/h).

From monitored values of train transits with traction vehicle ser. 163 [ČD] (in approximately equal thermal conditions) there was carried out an analysis of dependence of measured values of pressure in the sleeper bed on the speed of a passing vehicle. However, by this analysis from so far taken measurements there wasn´t found any significant dependence of pressures in a sleeper bed on the speed of a passing vehicle. Nevertheless, these results are still very preliminary, because the fact that follows from the location of a measuring spot is that trains pass through it at quite similar speeds, specifically from about 80 to 100 km/h and the difference is relatively very small to state a conclusion from these specific measurements about significantly increasing pressures in sleeper beds at increasing speed of vehicles on a track of so called classical construction.

Acknowledgment

This paper arose in connection with the solution of scientific research project of the University of Pardubice No 51030/20/SG530001. Co-author thanks for the support given.

Předloženo: 09.06.2013

Summary

ANALYSIS OF BEHAVIOR OF RAILWAYS TRACK SUBSTRUCTURE

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In this paper we discuss experimental measurements of pressures in the substructure of railway track on the railway line Pardubice hl. n — Jaroměř. In preparing the experimental measurement of pressures in the substructure of railway track were carried out using the findings from the strain gauge measurements and for extracting data from experimental measurements were fitted with strain gauge sensors in the substructure of railway track.

Resumé

ANALÝZA CHOVÁNÍ ŽELEZNIČNÍHO SPODKU

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V příspěvku je diskutována problematika experimentálního měření tlaků v pražcovém podloží na železniční trati Pardubice hl. n. — Jaroměř. Katedra dopravního stavitelství se dlouhodobě zabývá tenzometrickým měřením dopravních staveb. Při přípravě experimentálního měření tlaků v pražcovém podloží byly využity poznatky z provedených tenzometrických měření a pro získání dat z experimentálního měření byly osazeny tenzometrické snímače v pražcovém podloží a v zemní pláni tělesa železničního spodku.

Zusammenfassung

DIE ANALYSE DES VERHALTENS DER EISENBAHN UNTERKONSTRUKTION

Aleš Šmejda, Filip Ševčík

In diesem Papier diskutieren wir experimentelle Messungen von Drücken in den Untergrund Schwellen auf der Bahnstrecke Pardubice hl. n - Jaroměř. In der Vorbereitung der experimentellen Messung von Drücken in den Untergrund Schwellen wurden unter Verwendung der Erkenntnisse aus den DMS-Messungen und zum Extrahieren von Daten aus experimentellen Messungen wurden mit DMS-Sensoren in der Schwelle Untergrund der Eisenbahn Unterkonstruktion montiert durchgeführt.