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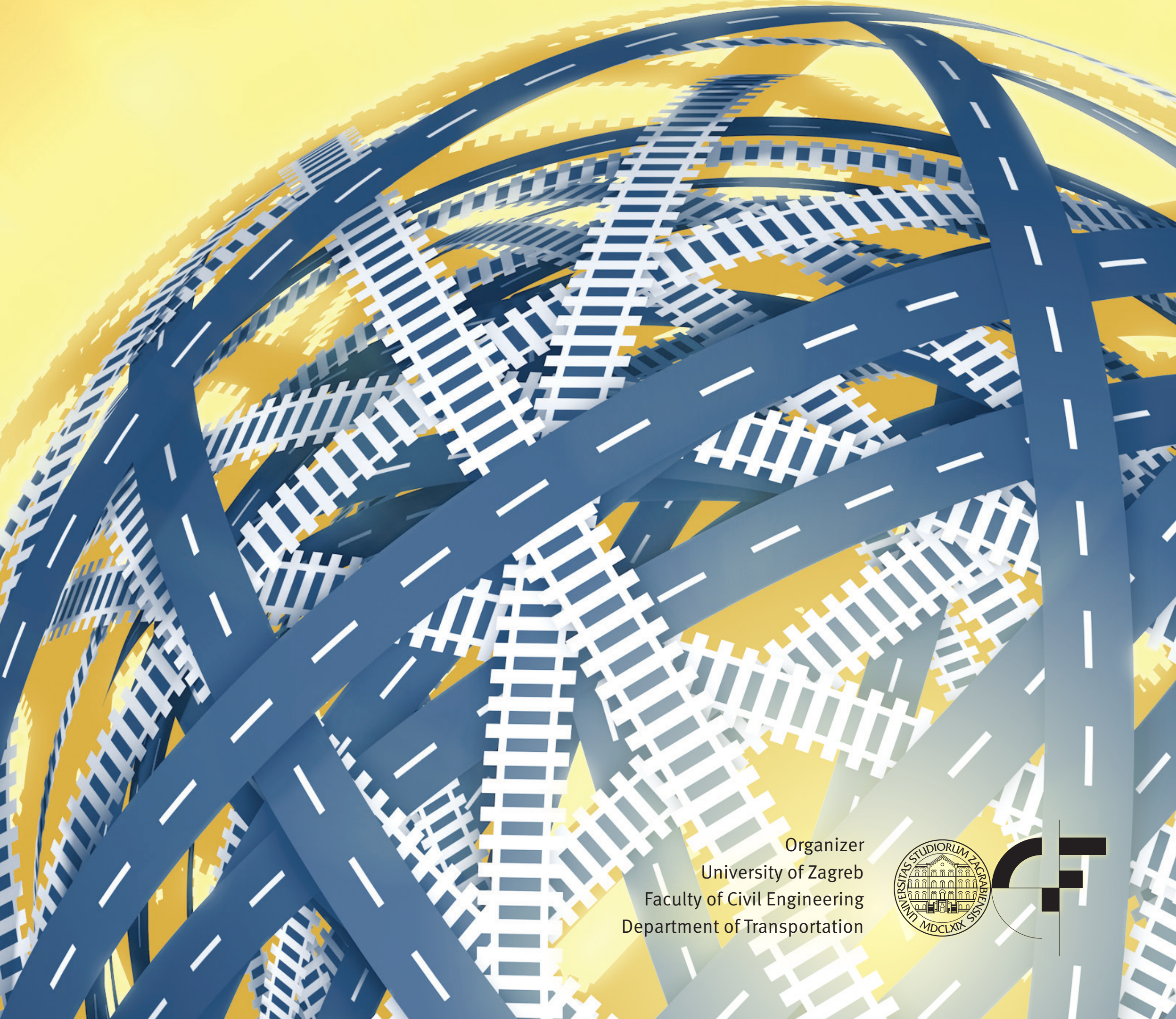
Road and Rail Infrastructure IV

Stjepan Lakušić – EDITOR



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TRACK MAINTENANCE AT THE END OF LIFE CYCLE

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Abstract

With determination of the railway track life cycle, time period of expected operation in satisfying the traffic needs for passenger and freight transport is also defined. During this period it is necessary to ensure expert maintenance activities. But what if expected life cycle is reached, but for some reason (usually budget constrains) it is not possible to start a new life cycle? More than 50% of railway network in Republic of Croatia is out of maintenance cycle. It means that average life cycle of track superstructure is overdue and it is no longer possible to ensure safe and reliable traffic within expected performances with regular maintenance activities which were anticipated during definition of the life cycle. In most cases infrastructure manager doesn't have a choice than to continue and adapt current maintenance activities and ensure safe and reliable railway traffic within constrains of approved budget. How to keep maintaining such track and which costs will be generated depends on conditions of track components and track geometry. Paper will address the issues of track maintenance for eastern part of lowland railway track R202 Varaždin – Dalj 130 km in length with superstructure 35 to 54 years old. This part of track is characterized with uniform track geometry and relatively small traffic demand and its superstructure can be divided in four characteristic types: joint track with wooden sleepers, continuously welded track (CWT) with wooden sleepers, CWT with concrete sleepers and direct elastic fastening (type ZEL) and CWT with concrete sleepers and non-elastic fastening (type K). Some proposals of adjusted maintenance of deteriorated track at the end of its life cycle will be presented.

Keywords: track, additional maintenance, renewal, extended life cycle

1 Introduction

With determination of the railway track life cycle, lifetime of expected track operation for passenger and freight transport is also defined in order to satisfy traffic demand. During relative long period of track operation it is necessary to ensure appropriate maintenance. However, what if expected life cycle of track is reached, but for some reason it is not possible to start a new life cycle? Key reasons for missing start of new life cycle are usually budget constraints. That makes infrastructure manager with no other choice than to keep on with maintenance in aim to ensure track reliability, availability and safety [1] within available budget.
It is a fact that more than 50% of railway tracks in Republic of Croatia is out of renewal – maintenance cycle [2]. This means the expected operative life track of track is overdue and it is no more possible to maintain a track in safe condition within expected performances with maintenance activities planned at the start of life cycle.

2 Maintenance in LC of railway track

Railway track, like any other system, has start of life cycle with its initial concept and end through disposal. With EN 60300-3-3:2004 Life cycle costing [3] any system can be defined through phases of initial concept, project, production, construction, operation and disposal. Main goal of track maintenance is to slow down the degradation of track quality during operation phase in order to ensure reliability, availability and safety.
Cycle "renewal – maintenance – renewal" is a classic systematic way of track maintenance [4]. After track construction follows a relative long time period of track operation for about 30-35 years. At the end of life cycle, track is usually seriously degraded, costs of maintenance are continuously rising and there is strong need for renewal. That usually means complete replacement of old superstructure with new one.
Alternative way of track maintenance is continuous maintenance, without renewal. It means permanent exchange of track components (deteriorated rails, sleepers, ballast) depending about degradation dynamics of track components. This way of track maintenance is not recommended [5], and it is only acceptable on lines with small traffic load, low operating speeds (up to 80 km/h) and in cases when infrastructure manager actually have no other choice.

3 Track condition at the end of life cycle on section Dalj – Pčelić

Today, main characteristic of railway infrastructure in Republic of Croatia is deterioration because of budget restrictions causing delays of planned renewals and need to implement speed restrictions in order to ensure safety of track operation. Such conditions unfortunately are also present on line R202 Varaždin – Dalj. It is regional line between northwest, northeast and central Croatia with mixed traffic. In last 15 years importance of this line is slowly decreasing.

Table 1 Track data for line R202 Varaždin – Dalj, RJ HŽI Istok, NS Osijek

	Track section	V max VR 2015/16 [km/h]	Renewal [year]	Age of section [years]	Length [m]	Section length – wooden sleepers [m]	Section length – concrete sleepers [m]	Wooden sleepers [units]	Average sleeper failure [%]	Max. sleeper failure [%]	Concrete sleepers [units]	Fastening type
1	Dalj – Osijek D. g.	40	1962	53	20072	20072	0	33453	17,43	33,97	0	TP/KD/SKL2
2	Osijek D.g. – Osijek	50	1962	53	2993	2993	0	4988	7,47	9,28	0	TP/KD
3	Osijek – josipovac	80	1974	41	7936	7936	0	13227	15,67	29,16	0	KD
4	Josipovac – Bizovac	80	1974	41	11261	596	10665	993	15,67	29,16	17775	KD/ZEL
5	Bizovac – Koška	80	1975	40	13488	8241	5247	13735	19,44	37,45	8745	KD/ZEL
6	Koška – Našice	80	1976	39	15474	3143	12331	5238	2,48	4,88	20552	KD/KB
7	Našice – Đurđenovac	80	1981	34	9039	9039	0	15065	16,47	24,26	0	KD
8	Đurđenovac – Z. Orahovica	80	1981	34	9922	9922	0	16537	18,85	25,34	0	KD
9	Z. Orahovica – Čačinci	70	1981	34	5800	5800	0	9667	9,93	22,34	0	KD/SKL2
10	Čačinci – Slatina	70	1981	34	18420	18420	0	30700	7,47	24,56	0	KD/SKL2
11	Slatina – Cabuna	80	1978	37	11635	5337	6298	8895	12,40	24,64	10497	KB/KD
12	Cabuna – Pčelić	80	1978	37	5002	5002	0	8337	22,00	25,38	0	KD
	Total				**131042**	**96501**	**34541**	**160835**			**57568**	

It is lowland line with mostly uniform geometry and possible speeds from 80 up to 140 km/h, with just a few curves where speed needs to be restricted. Last renewal was performed in period from 1962. to 1981. Infrastructure manager, HŽ Infrastruktura, RJ HŽI Istok, NS Osijek ensures and supervises maintenance of track section Dalj – Pčelić (131 km in length).
With last track renewal on section Osijek – Pčelić maximum speed was 100 km/h, but through time of operation, after expiration of expected life cycle and with increase of quality degradation it was necessary to implement speed restrictions [6].
In time period from renewal toward present day traffic load on this line is continuously decreasing from over 6 MBGT per year at the start of life cycle down to under 2 MBGT per year in 2015. Expected life cycle of this line was 33 years. Today track sections on this line are from 34 up to 54 years old. This means that life cycle of track is overdue and there is urgent need to implement, beside regular maintenance, additional maintenance activities.

4 Types of track on section Dalj – Pčelić

Every type of track is necessary to maintain with specific maintenance activities depending about track system and condition of track components. For rational accomplishment of maintenance activities, it is necessary to have some knowledge about expected duration of extended period of track operation up to date of prolonged renewal.
On lines where track renewal will happen in near future, it is only rational to perform minimal maintenance activities in correlation with speed restrictions on critical sections. If there are no plans for track renewal in foreseeable future, it is necessary to ensure additional maintenance activities in order to ensure track operation (in this case for 10 – 15 years).
According to available data, there are no plans for track renewal of line R202 Varaždin – Dalj in period 2016.-2020. [2]. In last decade continuous budget restrictions are affecting infrastructure manager, and considering decreasing importance of this line, renewal is not likely to happen in near future. Regular maintenance activities during life cycle of track in short mostly consists with replacement of track components, spot repairs, leveling-lining-tamping and weed control. On this line, at the end of track life cycle occurs a need for additional maintenance activities due to missing renewal of track.

4.1 Type 1: joint track

Joint track is present on track sections Dalj – Osijek Donji Grad and Osijek Donji Grad – Osijek, Fig. 1. Track system is wooden sleepers, rails type S45 and mixed types of fastening (screw spikes and K type). Weakest point of this track type are wooden sleepers due to old age (54 years).

Figure 1 Condition of track type 1

In last decade a limited maintenance activities were performed by NS Osijek in order to replace failed wooden sleepers (about 30% of all sleepers were replaced). Unfortunately, these maintenance activities were limited and insufficient due to budget constraints.
Because of very old age of wooden sleepers, number of defective sleepers on this track section is very high and in next period it is going to be even higher (expected life cycle of wooden sleeper is 30-35 years).
During regular maintenance activities on track sections it is necessary to perform additional maintenance activities – massive replacement of deteriorated wooden sleepers, replacement of wedged plates with ribbed plates, fastening type K only and with addition of ballast due to large works on sleepers replacement.

4.2 Type 2: continuously welded track (CWT) with wooden sleepers

CWT with rail 49E1, wooden sleepers and K fastening is present completely on track sections Osijek – Josipovac, Našice – Slatina and Cabuna – Pčelić, and just partly on sections Josipovac – Našice and Slatina –Cabuna, Figure 2. Weakest points of this track system are also wooden sleepers due to increased age.

Figure 2 Condition of track type 2

During last decade within regular maintenance a significant number of wooden sleepers were exchanged with limited budget. On this sections wooden sleepers are 35 to 43 years old, and in following years number of defective sleepers is going to be even higher due to old age (expected LC of wooden sleeper in good ballast is 30-35 years).
With regular maintenance activities, at the end of expected life cycle of track it is also necessary to execute additional maintenance activities – massive replacement of deteriorated wooden sleepers and addition of ballast due to large works on sleeper exchange.

4.3 Type 3: CWT with concrete sleepers and fastening ZEL.8

CWT with rail 49E1, concrete sleeper HŽ70 and elastic fastening ZEL.8 is partly present on sections Josipovac – Bizovac and Bizovac – Koška, Figure 3. Weakest point of this track system is poor condition of fastening.
Elastic direct fastening ZEL.8 is applied on concrete sleeper HŽ70 [7]. This type of fastening is without base plate, with visible degradation of clamp force due to degradation of rail pads and fastening pads, deformations on clamps, vertical screws and horizontal bars in sleeper body. Additional maintenance activities in this case includes partial replacement of ZEL.8 fastening with special new parts for UTZ fastening in combination with SKL-1 clamps for mounting on existing concrete sleepers HŽ70, Figure 4.

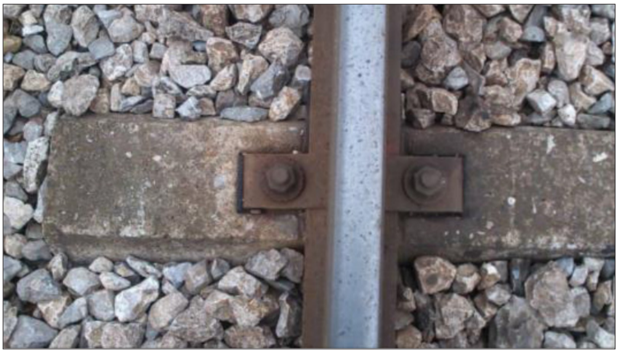

Figure 3 Condition of track type 3

Figure 4 Replacement of ZEL.8 fastening with compatible fastening UTZ

4.4 Type 4: CWT with concrete sleepers and K fastening

CWT with concrete sleepers HŽ70 and K fastening is present on sections Koška – Našice and Slatina – Cabuna, Figure 5. All track components of this track system are so far in good condition. With regular maintenance performed though a life cycle, at the end of track life cycle there is no need for additional maintenance activities for this track system.

Figure 5 Condition of track type 4

5 Additional maintenance versus renewal

For each type of track constructions costs of additional maintenance are calculated. Additional maintenance activities need to be performed in period 3-5 years in order to ensure availability, reliability and safety of traffic for expected period 10 to 15 years. Calculated costs are based on unit prices of materials and unit prices of maintenance services (data provided by HŽ Infrastruktura, Zagreb, 2016.). With unit prices based on existing contracts, additional maintenance costs are calculated for each type of track (costs of operating hindrances were not included). Costs of additional maintenance are compared with costs of track renewal (with brand new track components: rails 49E1, concrete sleepers PB85K/SKL-1, ballast and sub ballast).

Table 2 Additional maintenance costs versus costs of track renewal

Track type	Additional maintenance [kn/km]	Renewal [kn/km]	Add. maintenance/Renewal [%]
Type 1	722.000	3.644.212	19,81
Type 2	541.833	3.644.212	14,87
Type 3	440.000	3.644.212	12,07
Type 4	0	3.644.212	0,00

With presented 4 types of track systems, on this line so far type 4 has been most successful. Even after period of 40 years in operation, it is still compact and without significant signs of wear. In future it is expected to keep on with regular maintenance in correlation with actual traffic load. It is important to emphasize that costs of an additional maintenance does not exclude regular maintenance costs. Although additional maintenance costs are significantly lower than costs of renewal, they are just necessary alternative to ensure continuation of operation of traffic in safe manner and without speed restrictions. Described activities of additional maintenance cannot replace effects of track renewal. With track renewal life cycle will be linked with actual traffic load and actions of regular maintenance, with viable option for prolongation of life cycle without costs of additional maintenance.

6 Conclusion

Track types with wooden sleepers (type 1, type 2) have shown large demand for additional maintenance activities caused by limited durability of wooden sleepers. In a goal to ensure reliability, availability and safety of track operations at the end of its life cycle for additional period of 15 years, it is necessary to ensure costly activities of additional maintenance activities for sleeper exchange. Track type 3 with concrete sleepers and fastening system ZEL.8 at the end of life cycle has performed significantly better in comparison with track types with wooden sleepers (type 1, type 2), but not as good as type 4 (concrete sleepers, K fastening system) where additional maintenance activities are not needed at all. Future track renewals should be made with concrete sleepers only (or eventually synthetic sleepers) on all lines where possible (radii over 250 m, slope up to 15 ‰) where all components of sleeper (including fastening) are durable longer than expected life cycle of track. This will ensure expected life cycle of new track with regular maintenance depending on existing traffic load, but if need occurs, there would be an option for prolongation of track lifetime without significant additional maintenance activities and additional costs [8].
Renewal of line R202 Varaždin – Dalj on section Dalj – Pčelić is essential. Until conditions to ensure track renewal are present, it is necessary to adapt current track maintenance to actual track conditions with additional maintenance. When track renewal is about to be started, it is important to be performed depending on actual conditions on track sections. This means the line renewal should be first performed on track sections with wooden sleepers (type 1, type 2), and later, in following phase, on track sections with concrete sleepers (type 3, type 4).

References

[1] EN 50126:1999 Railway applications — The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

[2] Republic of Croatia, National program of railway infrastructure for period 2016. to 2020., NN 103/2015

[3] EN 60300-3-3:2004 – Dependability management. Application guide. Life cycle costing.

[4] Zoeteman, A.: Life cycle costs for managing railway infrastructure, Delft University of Technology, 2001

[5] Trameo, Investment and maintenance strategies, Final report, Graz University of Technology, 2006

[6] HŽ Infrastruktura (IM) database, RJ HŽI Istok, Nadzorno središte Osijek, 2016.

[7] Božičević, J.: Prilog povećanju sigurnosti i brzine u tehnologiji i eksploataciji željeznica, Disertacija, Fakultet za pomorstvo i saobraćaj, Rijeka, 1983.

[8] Alduk, W.: Održavanje u životnom ciklusu željezničke infrastrukture, magistarski rad, Građevinski fakultet Osijek, Osijek, 2013 (mentor: Marenjak, S.)