BASICS OF BUILDING A SECTIONAL SYSTEM OF TRACK CURRENT MAINTENANCE

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ABSTRACT

The current maintenance of a track in its essence is a struggle against the process of continuous accumulation of residual deformations and requires mobile control, professional readiness. Therefore, the work force capacity, organization of labor must meet the set tasks and conditions. The introduction of a sectional system of track maintenance, new technologies, automated complexes of track machines compels to revise the standards of track maintenance, the better use of production resources.

Keywords: *railway, track current maintenance, sectional system, organizational structure, number of track servicemen.*

Background. *With the purpose of improving the organization of track current maintenance, ensuring safe movement of trains and resource saving, the Regulation on a sectional system of track current maintenance was put in place on January 1, 2014 [1], and on the eve of 2016 the Regulation on management of track facilities of JSC Russian railways was approved [2].*

The transition to the sectional system provided for an increase in the level of planning and rational allocation of resources, improving the reliability of work of the operating staff, separation of control and track maintenance functions, and reducing operating costs.

Objective. *The objective of the authors is to consider basics of building a sectional system of track current maintenance.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, mathematical apparatus, evaluation approach.*

Results.

Labor and salary planning

The main indicators that characterize labor resources are:

– average number of employees;

– average monthly salary;

– costs for labor payment, as well as payroll fund of average number of employees;

– labor productivity.

The number of employees is determined depending on a track design, reduced freight intensity of a line, speed of movement, operating conditions and used track machines.

The staff of a track maintenance department is divided into five main production groups:

– track servicemen;

– foremen (released) for current maintenance and repair of track and artificial structures;

– operators of fault detecting trolleys;

– station on duty officers;

– other categories of workers.

Increase in the number of track servicemen

Such a process is carried out on the basis of the order of JSC Russian Railways dated 09.07.2009 No. 136 «On measures to improve current maintenance of a railway track» [3] taking into account the changes introduced.

Determination of the number of track servicemen is made separately for main, station tracks and switches according to the labor flow rate of each serviced section and correction coefficients, with the help of which the level of labor costs for a particular structure and specific operating conditions is established [3].

The number of track servicemen N_m for current maintenance of main tracks is determined by the formula

$$N_m = H \cdot L \cdot K_o, \quad (1)$$

where H – rate of labor costs; L – expanded length of the track (main or station one); K_o – correction coefficient, established depending on the design of a track, operating conditions etc.

According to the current maintenance of switches, the number is determined by the formula

$$N_{sw} = H \cdot N \cdot K_o, \quad (2)$$

where N – number of switches.

The estimated number of track servicemen is determined by the formula

$$N_{sw} = N_m + N_{st} + N_{sw}. \quad (3)$$

The value of the weighted average correction coefficient for the operating conditions is calculated in accordance with the regulations by the formula

$$K_o = \frac{\sum L_i (K_i - 1{,}0)}{L_{tot}} + 1{,}0, \quad (4)$$

where $\sum L_i$ – total extended length of the section with individual operating conditions, km (the number N of switches, pcs);

K_i – value of the correction coefficient for a section with individual operating conditions;

L_{tot} – total extended length of the section (total number of switches).

When using a complex or individual track machines, the number of track servicemen is reduced.

The methodical approach adopted in the existing normative documents, in which the features of the design of the track and operating conditions on specific kilometers are taken into account not by multiplying the labor cost norms by the correction coefficients, but are determined by multiplying the number of track servicemen calculated according to average norms by the weighted average coefficient, cannot be considered satisfactory.

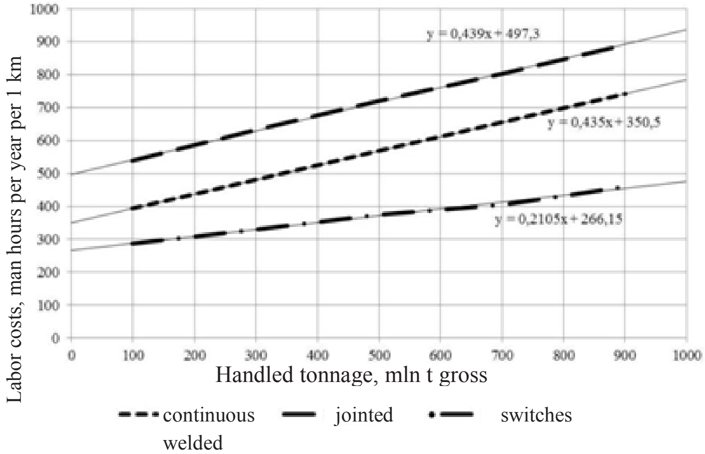
When calculating the general coefficient for operating conditions of the main tracks (K_{om}), according to the current regulations, it is necessary to take into account the fact that if any type of track repair and all the subsequent is not performed, labor cost norms increase by the corresponding coefficients. It is assumed that the performance of all intermediate repairs during the life cycle of the track structure is mandatory. However, interim repairs are assigned based on the actual state of the track.

Such an approach is not correct from the point of view of mathematical logic and is not acceptable in the case of a sectional system of management of track facilities, since it does not allow to distribute the

Table 1

The ratio of labor costs for current maintenance of the reference kilometer of various designs of track and switches

Types of works	Labor costs per 1 km a year for various designs of the upper structure of the track and switches, man hour per year		
	Continuous welded	Jointed	Switches on a reinforced concrete base
Adjustment of the geometry of the rail track	202	308	47
Replacement of the track upper structure elements	98	199	80
Planned works	154	91	109
Works independent on the volume of transportation	27	35	94
Total	481	633	330



Pic. 1. Graphs of dependencies of the actual labor costs of workers involved in current maintenance of 1 km of the track and the switch on the handled tonnage.

contingent of track servicemen along the length of the section in accordance with the actual labor intensity of the track-repair work.

Particularly large objections are caused by labor costs standards for the maintenance of receiving and departing and station tracks. They depend only on the type of rails and the kind of sleepers. Moreover, the standard for maintenance of receiving and departing tracks is only 3,5 % larger than in station and other tracks.

The standards for maintenance of switches on the main tracks depend on the freight traffic, but do not depend on the handled tonnage. For switches on receiving and departure and other station tracks, a general standard has been established, which is not related to the class and freight intensity of tracks.

Meanwhile, in accordance with the «Methodology of Classification and Specializations of Railway Lines» approved by the decree of JSC Russian Railways of December 23, 2015, the receiving and departure tracks intended for non-stop handling of trains belong to Class 3, and not intended ones to Class 4. The remaining station, access and other tracks – to class 5 [4].

The class of the switch is determined by the larger of the classes of connected tracks.

In this regard, the existing methodological approach to determining the costs of labor and materials for current maintenance of the railway track and formation of a contingent of track servicemen needed to be changed.

Substantiation of the norms for consumption of materials for current maintenance of the railway track, correction coefficients to the norms according to the proposed methodology is carried out depending on the class, the design features of the track, the total tonnage, the plan and profile of the track and other operating conditions [5].

Reference kilometers

To determine labor costs for current maintenance of a track, as typical designs of its upper structure, those that are sufficiently widespread and do not require reinforcement and additional labor costs are adopted. In connection with this, the concept of a reference kilometer of a track and a switch is introduced.

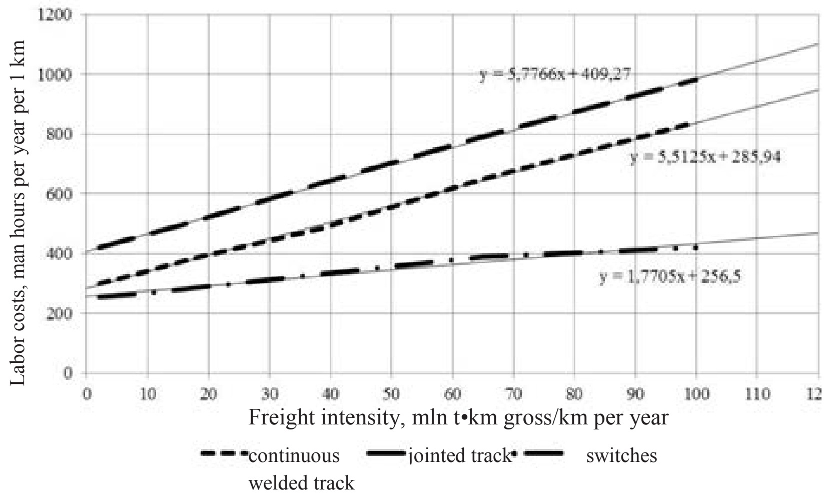
Reference kilometer for a continuous welded rail: R-65 rails of unlimited length, reinforced concrete sleepers, KB type fasteners, crushed stone ballast without a separation layer; a track section equipped with automatic blocking, located on platforms and inclines not steeper than 8 ‰, in straight or curved with a radii of more than 800 m; freight traffic is 26–50 mln t•km gross/km per year; handled tonnage is 201–400 mln t gross; train speed of 101–120 km/h – for passenger, 81–90 km/h – for freight trains.

Reference kilometer for a jointed track: rails of type R-65 with a length of 25 m, wooden sleepers, fasteners of type DO, ballast crushed stone without a separation layer; a track section equipped with automatic blocking, located on platforms and inclines

Table 2

Calculation of the normative number of track servicemen involved in current maintenance of H track maintenance section (2016)

Department/Section of calculation	Length (km)	Quantity (pcs)	Estimated number	Number (Kf = 1.00)
Enlarged brigade for PPR No. 1 Igr				
Main track	12,7		1,020	1,020
Station, access and other tracks	14,1		3,218	3,218
Receiving-departure tracks	6,9		1,368	1,368
Switches		114	13,365	13,365
Derailing tongues		42	1,680	1,680
Maintenance of unguarded crossings (number of tracks)		1	0,100	0,100
Total for the section:			21	21
Linear section for urgent works No. 10 st.				
Including the magnitude of the contingent when track machines are applied			-0,150	-0,150
Main track	17,2		2,500	2,500
Station, access and other tracks	11,8		2,169	2,169
Receiving-departure tracks	3,2		0,695	0,695
Switches		46	5,758	5,758
Maintenance of unguarded crossings (number of tracks)		7	0,700	0,700
Total for the section			12	12
Total for the structural unit:			202	202
Including:				
Main track	199,9		48,664	48,664
Station, access and other tracks	157,5		32,313	32,313
Receiving-departure tracks	64,8		12,018	12,018
Switches		645	101,871	101,871
Derailing tongues		68	2,720	2,720
Dead crossings		1	0,100	0,100
Maintenance of unguarded crossings (number of tracks)		37	3,700	3,700
Including the magnitude of the contingent when track machines are applied			-2,862	-2,862



Pic. 2. Graphs of dependencies of the actual labor costs of workers involved in current maintenance of 1 km of track and switch point, on the freight intensity.

not steeper than 8 ‰, in straight or curved with a radii of more than 800 m; freight traffic is 26–50 mln t • km gross/km per year; handled tonnage is 201–400 mln t gross; train speed of 101–120 km/h – for passenger, 81–90 km/h – for freight trains.

Reference switch: ordinary, centralized type R65, grades 1/11 or 1/9 with a bolted frog, lying on the main track, reinforced concrete beams, crushed ballast; freight traffic of the track is 26–50 million t • km gross/km per year; train speed of 101–120 km/h – for passenger, 81–90 km/h – for freight trains.

List, scope of work and labor input

The basic list of works on current maintenance of a continuous welded jointed track and switches is made on the basis of an analysis of regulatory documents and statistical data from the track maintenance sections of five infrastructure directorates (Moscow, October, Kuibyshev, Volga, West Siberian) according to the actual volumes for 2014.

For a continuous welded design of a track, the list of works contains 88 items, for jointed design – 90 and maintenance of a switch – 76.

Volumes of work for which there are indications in the regulatory documents of the periodicity of their implementation were determined by multiplying the number of meters available per kilometer of the track by the frequency of execution. The volumes of the remaining work were determined by the statistical processing of the collected data.

In all cases, labor costs are the result of multiplying the amount of work by the time norm, taking into account the dimension of the meters.

All the work performed during current maintenance of a continuous welded track is distributed as follows: for adjustment of the rail track geometry – 9 items; to replace the elements of the upper structure of the track – 24; planned works – 22, works, independent of the volume of transportation – 33 items. In the last section there are operations related to maintenance of the roadbed, crossings, small culverts, signal signs.

Summary data on the ratio of labor costs for current maintenance of reference kilometers of track and switches are given in Table 1. Analysis of the data in this table shows that labor costs per 1 km of the jointed track in the reference conditions are 1,32 times larger than for a continuous welded track, and maintenance of one switch makes up 68,6 % of the maintenance of 1 km of a continuous welded track. The greatest labor costs are attributed to adjustment of the geometry of the track gauge – 42–49 % of the total costs for maintenance of the track and 14 % – for maintenance of switches.

The labor costs for performing work that does not depend on the volume of transportation do not exceed 6 % of the total costs for maintaining linear track structures and 28 % for maintenance of switches. In the latter case, a significant cost (23 %) falls on the struggle with snow to ensure trouble-free operation of switches in the winter. On sections of a continuous welded rail, 32,4 % of labor costs fall on correcting the drawdowns and misalignments of the track by tampering the sleepers with electric tamping rods and laying the adjusting pads. On sections of a jointed track with wooden sleepers, 27 % of labor costs go to the same purposes (tampering of sleepers with electric tamping rods, flapping tamping rods and folding cards), and 20,5 % – to replace wooden sleepers.

For operating conditions other than the reference, labor costs were determined using the same lists of work, but with other intervals of traffic intensity and handled tonnage.

The graphs of the dependence of labor costs on the handled tonnage are shown in Pic. 1. It follows from the graphs that the rate of increase in labor input as the tonnage is developed for both designs is the same, and the labor costs for a continuous welded track is 1,32 times smaller. Dependence of labor costs on freight intensity (Pic. 2) is of the same nature.

Labor cost norms of workers

Considering the fact that the normative operating time of track servicemen in 2014 was 1970 hours, we will switch from labor costs in man hour/year to the norms of person/year.

On the basis of the obtained data, using the regression analysis, the equations of dependences of the labor cost norms (people per year) for workers involved in current maintenance of a track, on freight intensity and the handled tonnage were found [5]:

a) continuous welded track

$$H_{cwt} = 0,055+2,7 \cdot 10^{-3}FI+2,2 \cdot 10^{-4}T; \quad (5)$$

b) jointed track

$$H_{jt} = 0,136+3,0 \cdot 10^{-3}FI+2,2 \cdot 10^{-4}T; \quad (6)$$

c) switches

$$H_{sw} = 0,1+1,0 \cdot 10^{-3}FI+2,2 \cdot 10^{-4}T, \quad (7)$$

where FI – freight intensity of a track section, mln t • km gross/km per year; T – total tonnage, mln t gross.

Correction coefficients are established taking into account normative documents, actual labor costs and questionnaire survey of experts – road masters and deputy chiefs of track maintenance sections, as well as the influence of structural features of the continuous welded, jointed tracks and switches on labor costs. For a continuous welded track, such features are primarily the length of strings, construction of fastenings, presence or absence of a sub-ballast separation layer and auto-locking. For a jointed track – a kind of sleepers and ballast. For switches – type of rails, brand and construction of a bolted frog, types of beams and ballast, snow protection devices, climatic conditions of the region. The effect of the plan and profile of the track, the speed of train traffic, the specificity of operating conditions that differ from the reference ones, are also taken into account by the correction factors.

The data for calculating the number of track servicemen are entered into the program of the unified corporate automated labor resource management system (EK ASUTR) (in the track maintenance section the data are taken from the statistical reports of AGO-1, the technical passport: reporting forms TsO-4, TsO-5, PO-1, PO-8. A sample calculation of the number of track servicemen on a computer is given in Table 2.

Structure of track maintenance section and reduced track length

Track maintenance sections are structural subdivisions of the infrastructure directorate. The track maintenance section is entrusted with supervision and control over the condition of the track and structures, implementation of urgent, priority and planned work on the current maintenance of the track.

The organizational structure of the track maintenance section is constructed taking into account the reduced length and reduced freight intensity of the serviced sections, the level of mechanization of track operations, the applied technological processes and the accepted organization of labor. According to the current regulations, the reduced length of the track served by the track maintenance section is 200–300 km on double-track and multi-track sections, and 150–200 km on single-track sections.

Table 3

Coefficients of reduction of track length to 1 km of reference kilometer

Name of a track	Design of a track, a switch	Labor costs norm, person per km per year	Coefficient of reduction
Main	Continuous welded on reinforced concrete sleepers	0,298	$\alpha_m=1,0$
Main	Jointed on wooden sleepers	0,399	$\alpha_m^{'}=1,34$
Receiving and departure	Continuous welded on reinforced concrete sleepers	0,141	$\alpha_{rd}=0,47$
Receiving and departure	Jointed on reinforced concrete sleepers	0,150	$\alpha_{rd}^{'}=0,50$
Receiving and departure	Jointed on wooden sleepers	0,225	$\alpha_{rd}^{''}=0,75$
Station	Jointed on reinforced concrete sleepers	0,130	$\alpha_{st}^{'}=0,44$
Station	Jointed on wooden sleepers	0,170	$\alpha_{st}^{''}=0,57$
Switches			
Main	Reinforced concrete beams	0,199	$\beta_m=0,67$
Main	Wooden beams	0,211	$\beta_m^{'}=0,71$
Receiving and departure	Reinforced concrete beams	0,141	$\beta_{rd}=0,47$
Receiving and departure	Wooden beams	0,170	$\beta_{rd}^{'}=0,57$
Station	Reinforced concrete beams	0,130	$\beta_{st}=0,44$
Station	Wooden beams	0,150	$\beta_{st}^{'}=0,50$

The reduced length of the railway track is calculated in accordance with the requirements of the order of JSC Russian Railways of 09.05.2005 No. 322r. It is determined by the formula:

$$L_{red}=l_m^{'}+0,75l_m^{''}+0,4l_{st}+\frac{N_{sw}}{20}, \qquad (8)$$

where $l_m^{'}$ *– length of the first track, km;*

$l_m^{''}$ *– length of the second (third etc.) main track, km;*

l_{cm} *– length of the station track, km;*

N_{sw} *– number of switches, sets.*

The definition of the reduced length by formula (8), in our opinion, is incorrect, has no scientific justification, is nevertheless recommended by normative documents [4] for practical application.

In this regard, we use the author's approach to determining the reduced track length, based on the ratio of labor costs to current maintenance of 1 km of the construction of the track and the track of the reference kilometer.

The length of all tracks and switches is reduced with the correction coefficients to 1 km of the reference kilometer of the continuous welded track on reinforced concrete sleepers by formula

$$L_{red}=\alpha_m l_m+\alpha_{rd} l_{rd}+\alpha_{st} l_{st}+\beta_m n_m+\beta_{rd} n_{rd}+\beta_{st} n_{st}, \qquad (9)$$

where l_m, l_{rd}, l_{st} *– expanded length of tracks of main, receiving-departure and station;* n_m, n_{rd}, n_{st} *– number of switches, laid on main, receiving-departure and station tracks.*

The values of the correction coefficients are given in Table 3.

Organizational structure of operational sections

The operational section, under the direction of the senior road master or the head of the section of the track (consisting of 3–5 linear sections (subdivisions)) without linear departments is the main subdivision of the track maintenance section.

The head of the site manages the unit, plans scheduled and urgent work together with the road masters, monitors the quality of their implementation.

A road master supervises the linear section (subdivision), his main task of which is to perform current maintenance of the track and structures on the fixed line segment in a condition ensuring the safety of train traffic with established speeds.

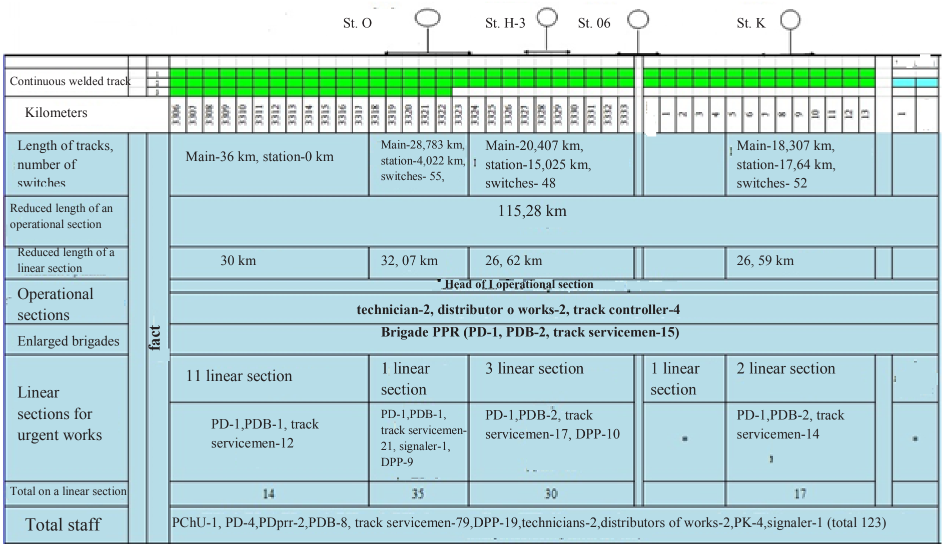
On the linear sections, brigades are created for urgent works with a number of 10–12 track servicemen.

Work on the current maintenance of the track is carried out under the guidance of foremen (released) and road masters in accordance with paragraph 2.3 of the instructions for ensuring the safety of train traffic during track works approved by the decree of Russian Railways No. 2790r dated 29.12.2012.

For implementation of planned work, including with the use of machined complexes, an enlarged brigade of 15–25 track servicemen, headed by a road master and two foremen, operates on the section. At the same time, in any brigades, the number of track servicemen who completed training and passed the exams for signalers should be at least 30 % of the actual number of personnel.

For the periodic inspection and inspection of the track, railway facilities, switches, artificial structures, roadbeds, track structures and rail chains, the line supervisor of the state of the railway line from among the foremen of the track is introduced on the linear section.

To ensure the maintenance of reporting and accounting records, electronic document management, marking of track facilities on the operational section in accordance with the standard staffing of track maintenance sections, positions of technicians are introduced.



Pic. 3. Linear scheme of administrative division of H track maintenance section.

The number of foremen is determined by the standards of controllability of middle managers, foremen in the track facilities and structure management approved by Russian Railways on June 7, 2016 [6], and the standard staffing table for track maintenance sections (Russian Railways decree No. 1452r dated July 9, 2009).

Using the updated methodology and algorithm for determining the reduced length of tracks and the number of structural subdivisions of the track maintenance sections, samples of the administrative structure of the basic track maintenance section have been developed in a graphic form (Pic. 1).

Currently, plans and summary reporting on the work carried out on the current maintenance of the track and structures are formed in a single corporate automated infrastructure management system (EK ASUI). And one of the most important indicators being accounted in the reporting is the efficiency of the use of labor resources and, first of all, labor productivity.

In the track maintenance section (on operational sections), the productivity of labor (P_l) is determined by the amount of work in tonne-kilometers gross (Pl_{gr}) per worker in the transportation activities, according to the formula

$$P_l = \sum \frac{Pl_{gr}}{N_{av}}, \quad (10)$$

where N_{av} – average number of employees.

Conclusion. *Tonne-kilometer work depends little on the activity of the track maintenance section, at the same time, the number of employees is justified by the regulations, which directly depend on the parameters of the operational work: freight intensity, speed of traffic, tonnage handled on the section. Therefore, the considered norms of labor costs for current maintenance of the track, the methods given in the article, allow us, in our opinion, to use labor and financial resources more rationally to ensure the reliability of the track and safety of train traffic.*

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