Enhancement of local traffic management systems using information technology

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Abstract. In the article the analysis and researches on optimization of the process of transfer and assembly of local wagons at freight stations in railway transport are carried out. In particular, on the basis of the results of the work a structural scheme for effective organization of the wagon flow has been carried out to optimize the work on formatting of multi-group trains serving intermediate stations located on the railroad site at technical stations, to improve the technologies of transfer and withdrawal of wagons to intermediate stations. Chukursay sorting station under the jurisdiction of "Uzbekistan Railways" JSC and intermediate stations (mainly located on the southern line), where the formation of multi-group trains from the sorting station is planned, were selected as the object of research. Has been researched proportion of staying local wagon-flows over-standard at stations and railroad haul. According to it, the highest number of stays is in the proportion of technical stations (42% in relation to total stays) and intermediate stations (31% in relation to total stays). A target function has been developed to transfer local wagon flows to and from intermediate stations. In order to solve the problems, a program for determining the layout scheme of wagons in the composition of the train has been developed and proposals for its introduction into practice have been made.

1 Introduction

Today, speed and quality of transportation when transporting goods is the most important factor in ensuring the competitiveness of any type of transport. The reduction in freight delivery time is the basis for the complete satisfaction of Railway customers ' requirements. In a market economy, strong ties between customers and the carrier remain only when the contract between the two parties is fully followed.

The time of delivery goods in rail transport is one of the main indicators in transportation work. Also, the acceleration of the flow of wagons causes a decrease in the time of delivery of goods in rail transport. In order to reduce time of delivery of goods to their destination, it is advisable to rationally organize the flow of wagons In order to reduce time of delivery goods to their destination, it is advisable to rationally organize wagon-

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flows and analyze the factors affecting the acceleration of their movement and develop measures to improve these factors.

Currently, the coverage of multi-group train processing is increasing at almost all technical stations of the Joint-Stock Company "Uzbekistan Railways "(in text "UTY" JSC). Also, taking into account the principle of timely delivery of goods, serious attention is paid to the issues of reducing the time of transportation of goods transported by this type of train and maintaining the quality of cargo. In the field of Railways, optimization of time spent on processes carried out at technical stations with multi-group trains and rational organization of movement local wagons on moving stations of this type of train is one of the pressing problems.

Several scientific works have been carried out on issues of organizing local wagon-flows at railway stations [1-11]. During study of these scientific works in research work, was concluded that issues of organizing of local wagon-flows on basis of information technology were not sufficiently studied.

2 Materials and methods

The development of a plan for the rational organization of the flow of wagons will cause the acceleration of the movement of the flow of local wagons on these plots. The local wagon-flows is an important element of the carriage work. On some railways, work with local wagons accounts for 60-80% of all work size [12].

In order to rationally organize local wagon-flows, it is important to first develop a "structural scheme for effective organization wagon-flows", depending on the direction of movement (Figure 1).

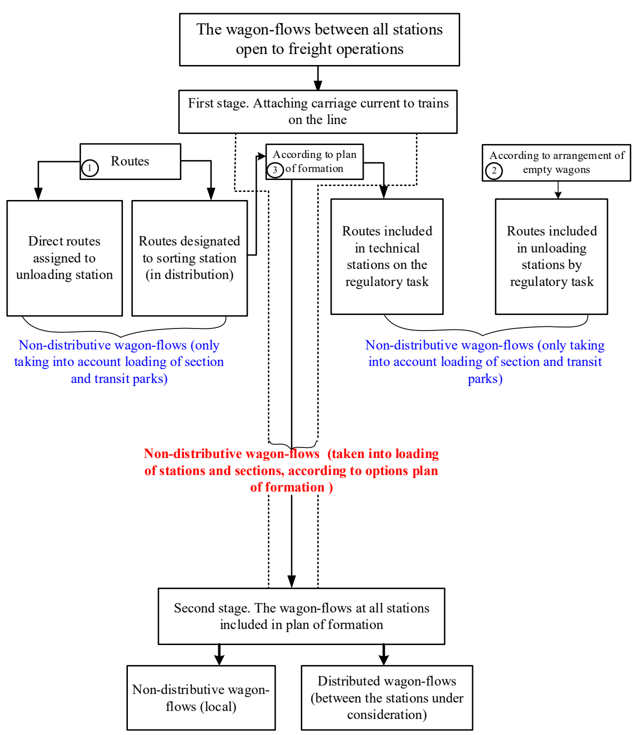

Fig. 1. Structural scheme for effective organization wagon-flows.

 https://doi.org/10.1051/e3sconf/202458307016

The research of the "Structural scheme for effective organization wagon-flows" and the formation of multi-group trains in accordance with the train layout plan remain an urgent issue for railway stations.

Therefore, the research work needed the process of forming (distributing) multi-group trains at technical and intermediate stations. For this, the "Chukursay" sorting station under "UTY" JSC and the intermediate stations (located mainly on the southern line) where the multi-group train layout is planned at this station were chosen as the object of research. It is envisaged Chukursay sorting station will form multi-group trains in 5 directions according to the destination of the wagons contained in the train to be processed (Figure 2).

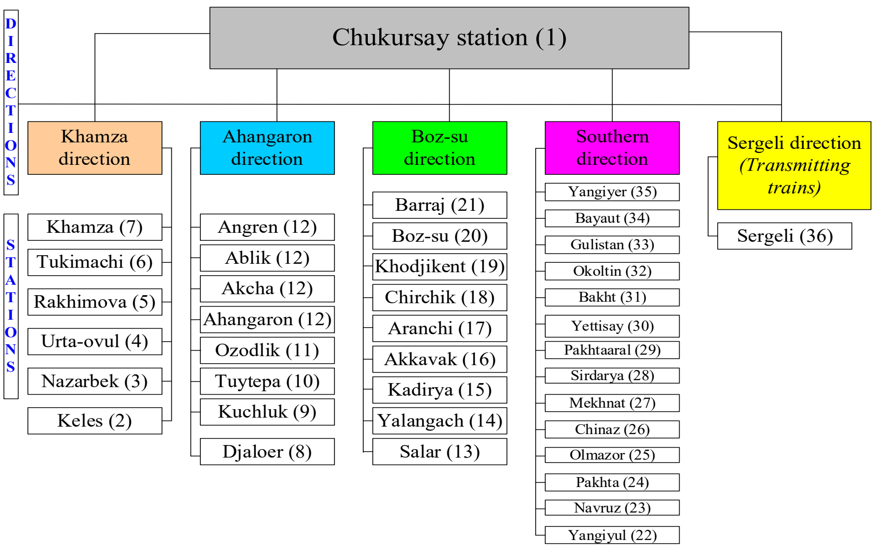

Fig. 2. Plan for multi-group trains station of Chukursay on directions and stations.

During the research work, it was found that it would take an average of up to 90 minutes to formatting multi-group trains on the southern directions [13-15].

On the basis of chronometry observations, an analysis of transmission of wagons to intermediate stations railway section was carried out. The results of research telegram natur sheets (DU-1) of trains that were drawn up on the southern line for a month are shown in Figure 3.

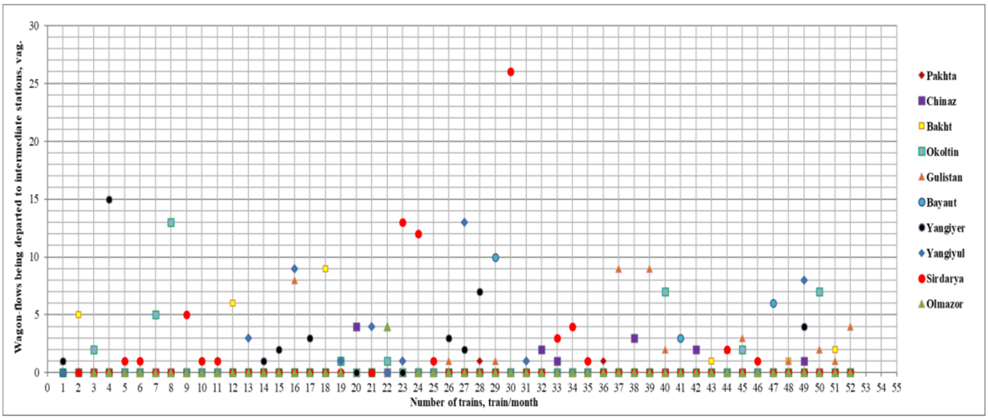

Fig. 3. Results of chronometry transmission wagons to intermediate stations on the railway section.

According to the results obtained, it can be seen that a large part of wagon-flows is distributed to the stations of Yangiyul, Sirdarya, Okoltin, Gulistan and Yangiyer (Figure 4).

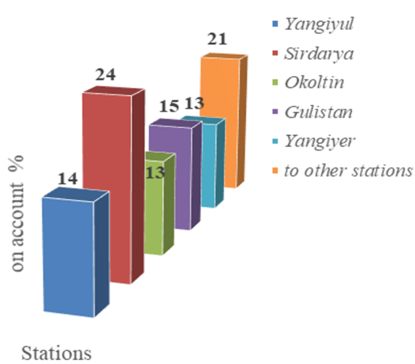

Fig. 4. Distribution of wagon-flows transferred from the technical station to intermediate stations on railway section.

It can be seen the local wagon-flows current that is delivered to its destinations within a multi-group train will react in the following way to situations where it remains above normal (Figure 5).

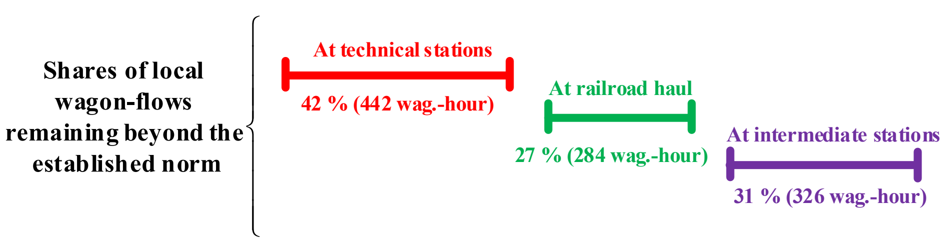

Fig. 5. Shares of local wagon-flows remaining beyond the established norm.

According to Figure 5, it can be seen that the most standing-up shares of the local wagon-flows are observed at stations (technical and intermediate). The normalization time of stay local wagon-flows at technical stations has been researched in detail in works [16, 17]. For this reason, it has not been sufficiently studied to conduct local wagon-flows at intermediate stations and to normalize the times of stay. In the research work, the target function of transmitting local wagon-flows to (/and from) intermediate stations was developed (Figure 6).

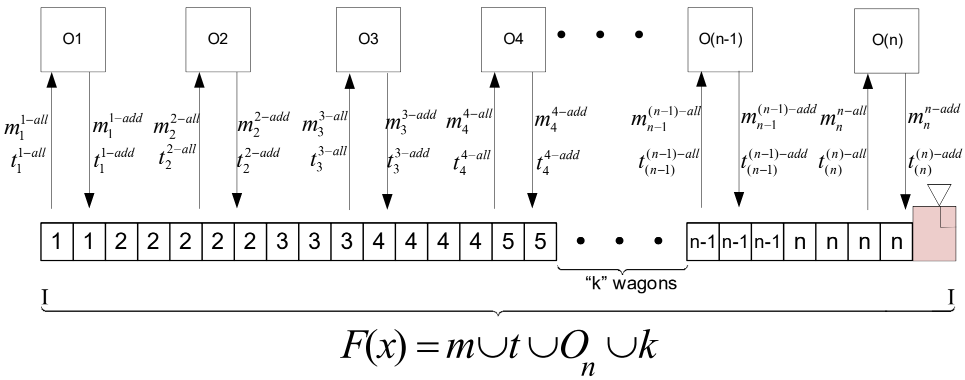

Fig. 6. The target function of transmitting local wagon-flows to (/and from) intermediate stations.

According to Figure 6 basis of target function depends on number of wagons in multi-group train (m), time of transmission and withdrawal of wagons to (/and from) intermediate stations (t), the number of intermediate stations $(\mathrm{O_n})$.

Therefore, if the following attitude is appropriate movement of local wagon-flows will be used wisely:

$$\mathrm{F(x)} = \left\{ \begin{matrix} \mathrm{m}_{(n)}^{(n)\text{-all}} - \mathrm{m}_{(n)}^{(n)\text{-add}} = 0 \\ \mathrm{t}_{(n)}^{(n)\text{-all}} \to 0 \\ \mathrm{t}_{(n)}^{(n)\text{-add}} \to 0 \\ \mathrm{o_n} \to \min \\ \mathrm{k} \to \max \end{matrix} \right\} \quad (1)$$

We define set of factors (*A*) that affect movement of local wagons in acceleration. If the set of influencing factors is treated as follows, it will be possible to achieve the highest indicators of efficiency in this plot:

$$\mathrm{A} = \begin{cases} \mathrm{f}\,(\mathrm{n}, \Theta, \mathrm{T_{int}}, \phi_{\mathrm{tr}}, \mathrm{L_{sec}}, \mathrm{L_{is}}, \psi_{\mathrm{occ.p}}, \psi_{\mathrm{occ.f}}, \mathrm{i_{s.tr}}, \mathrm{S_{fn}}, \mathrm{S_{fs}}, \ldots) \to \min \\ \mathrm{f}\,(\mathrm{X}, \mathrm{Y}, \mathrm{D_{occ}}, \mathrm{W_X}, \mathrm{L_V}, \mathrm{G_V}, \mathrm{v_{sp}}, \ldots) \to \max \end{cases} \quad (2)$$

where is A – a set of accepted values of the parameters being optimized, consisting of several elements.

O – number of intermediate stations located between technical stations;

Θ – number of processes performed at intermediate stations;

T_{int} – standing time of local trains at intermediate stations;

ϕ_{tr} and $\mathrm{D_{occ}}$ – respectively, number of intermediate station tracks and their share of occupancy;

L_{sec} *and* L_{is} – respectively, distance between railway sections and intermediate stations;

$\psi_{occ.p}$ and $\psi_{occ.f}$ – respectively, level of occupancy section’s with passenger and other freight trains;

$i_{s.tr}$ – slope of tracks on the railway section;

S_{fn} and S_{fs} – natural and technogenic factors;

X and Y – wagon-flows of moving in odd and even directions, respectively, in relation to location of intermediate stations;

W_x – number of locomotives performing shunting work at intermediate stations or their types (train locomotive or shunting locomotive);

L_v *and* G_v – respectively, conditional length and weight norms of trains on the section;

v_{sp} – section speed.

The problems of rational organization local wagon-flows are due to lack of proper distribution of shunting work performed at intermediate stations located on these railway section [18].

The length of time spent on shunting work performed with local wagons at intermediate stations located on railway section depends on number of wagons to be added and separated at this station. When the number of wagons to be added and separated at the intermediate station is large (or location of wagons in train is uneven), there will also be a lot of time spent on shunting work performed with these wagons. Hence, function of time $(t_i^{add\text{-}all})$ spent on shunting work has a proper proportional effect on the number of wagons to be added and separated at intermediate stations and on the layout functions of these wagons as part of the train:

$$f(t_i^{add\text{-}all}) \square\ f(S_i), f(m_i) \quad (3)$$

where is S_i – location of wagons whose final destination as part of the train is designated as *i*-intermediate station;

m_i – number of wagons being added and allocated at station *i* (in subsequent calculations, depending on number of wagons being added and allocated, m_i may have a value of (-) or (-)):

$$m_i = m_{add\,(i)} + m_{all\,(i)}, \text{wagons} \quad (4)$$

where is $m_{add(i)}$ *and* $m_{all(i)}$ – respectively, number of wagons being added and allocated at station *i*.

If the arrangement of the wagons whose final destination is designated as an *i*-intermediate station within train is irregular, the time to separate these wagons from the train will also increase.

This results in excessive shunting flights and costs. With the reduction of shunting flights at intermediate stations, it is possible to achieve an acceleration wagon-flows.

Depending on size and classification of the work being carried out, duration time of allocated and addition of wagons from the train depends on:

- to type of locomotive carrying out shunting work (train locomotive or shunting locomotive);

- to location of the wagons being allocated and added (at the head of train, at the back of train or in the middle of train).

The formulas for calculating t_{add} and t_{all} times for the above cases are given in Table 1.

Table 1. Table of calculation spent time on the performance of shunting work related to allocation and addition of wagons at intermediate stations.

		Allocation time, min.	Addition time, min.	Separation time, min.
When the shunting works were done with a train locomotive	From head of train	$4,67 + 0,19 \cdot m_{all}$	$3,97 + 0,22 \cdot m_{add}$	$8,15 + 0,29 \cdot m_{all} + 0,23 \cdot m_{add}$
	From back of train	$11,76 + 0,61 \cdot m_{all}$	$11,52 + 0,37 \cdot m_{add}$	$15,53 + 0,46 \cdot m_{all} + 0,49 \cdot m_{add}$
	From middle of train	$5,59 + 0,24 \cdot n_{w.d.} + 0,20 \cdot m_{all}$	$5,05 + 0,24 \cdot n_{w.d.} + 0,21 \cdot m_{add}$	$10,15 + 0,33 \cdot n_{w.d.} + 0,29 \cdot m_{all} + 0,21 \cdot m_{add}$
When the shunting works were done with a shunting locomotive	From back of train	$3,75 + 0,46 \cdot m_{all}$	$2,05 + 0,06 \cdot m_{add}$	$5,95 + 0,46 \cdot m_{all} + 0,18 \cdot m_{add}$

All numbers in the formulas given in Table 1 are empirical coefficients [19].

m_{add}, m_{all} – number of wagons being added and allocated at intermediate station.

$n_{w.d.}$ – the number of wagons to be withdrawn, disconnected from of the train, before performing shunting work at intermediate stations.

Under table 1, when shunting work is done with a train locomotive, there is a tendency for trains to remain standing above normal at intermediate stations.

3 Results and discussion

There will be a need to use modern information technologies to systematize work performed with multigroup train that are planned go to intermediate stations and optimize time consumption. In the research work, a program was developed to determine layout scheme of wagons in the composition train's.

The developed program is written in the C# programming language, which provides the following information based on its functional capabilities:

- total number of wagons in the composition of freight trains receiving into the station's receiving park, wag.;
- the number of corresponding routes wagons in the train;
- information about the layout scheme of wagons in the composition train's;
- accounts spent time on performance of shunting work, etc.

The task of developed program: The organization of train work allows you to pre-determine the layout scheme of the wagons in the composition of multi-group trains, which is envisaged receiving into the station, ensure the safety of movement and speed up the transportation process. For this reason, the efficient use of sorting and receiving, depart parkways on the basis of rapid planning is important in rail transport. The performance of sorting work at railway stations will depend on the number of wagons and groups in the receiving train, the speed in the implementation of the Manors and the number of wagons of the planned composition to be distributed, taking into account the length of the sorting track. This software tool makes it possible to effectively use the station tracks based on the pre-determination of the layout scheme of the train-containing wagons, which receiving into the station.

The screenshot of the program for determining layout scheme of wagons in the composition train's, which is envisaged for admission to the railway station, is shown in Figure 7.

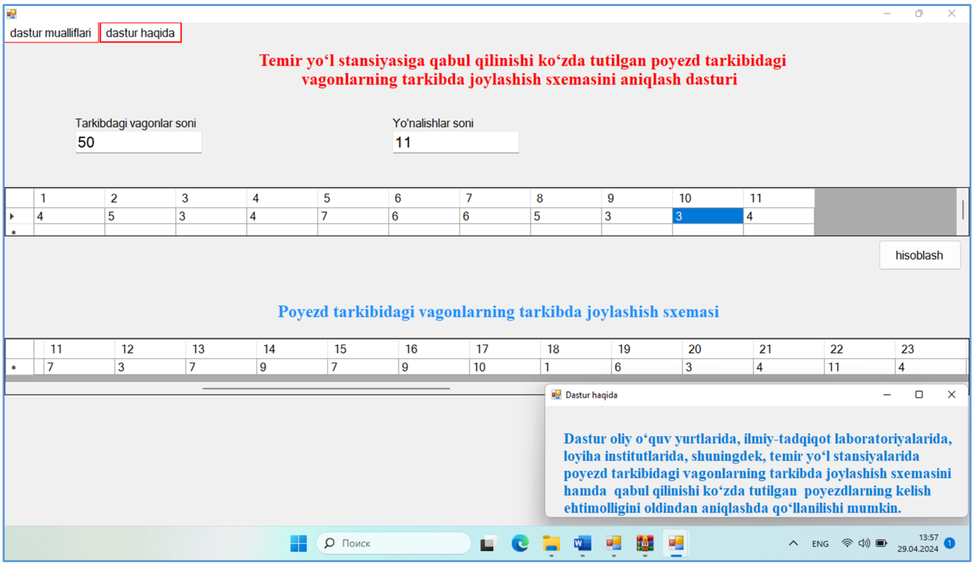

Fig. 7. Screenshot of program for determining layout scheme of wagons in the composition train, which is envisaged receiving into the railway station.

4 Conclusion

As a conclusion based on the results obtained from the research work, it can be said that the following proposals can be developed to normalize stopping times of wagons at intermediate stations:

1. It was found that the proportion of local wagon-flows exceeding standard of standing time in a railway section was in the ratio of 42% in technical stations, 27% in railroad haul, 31% in intermediate stations.
2. Application of information technology in normalizing stopping times of wagons at stations;
3. Preset departing times for freight trains, i.e. introduce a fixed graph in organization of train traffic;
4. Normalization of train processing times at technical and intermediate stations to speed up wagon-flows on railway site;
5. It is advisable to increase the number of shunting locomotives for intermediate stations, where a large part of the flow of wagons is directed;
6. Implementation of mathematical solutions to minimize standing times of wagons at freight facilities located at intermediate stations, etc.

This research was supported by a business agreement from the 2022 JSC "Uzbekistan Railways", Tashkent State Transport University, Republic of Uzbekistan.

References

1. D. Kozachenko, V. Bobrovskyi, I. Skovron, J. Jablonskytė, *Improving the efficiency of multi-group trains formation*, in Transport Means-Proceedings of the International Conference, pp. 1083-1089 (2019)
2. R. O. N. G. Ya-ping, Journal of Transportation Systems Engineering and Information Technology **19(4)**, 187 (2019)
3. D. Butunov, Z. Kalimbetova, S. Abdukodirov, et al., E3S Web of Conferences **460**, 06002 (2023)
4. R. O. N. G. Ya-ping, Q. I. Xiang-chun, L. I. Bo, L. I. U. Min, Journal of Transportation Systems Engineering and Information Technology **17(6)**, 193 (2017)
5. V. I. Bobrovskkyi, I. Y. Skovron, Science and Transport Progress **19**, 88-93 (2007)
6. D. Butunov, S. Buriyev, S. Abdukodirov, I. Abdumalikov, E3S Web of Conferences **402**, 03017 (2023)
7. I. Belošević, S. Milinković, M. Ivić, P. Marton, E3S Web of Conferences **135**, 02026 (2019)
8. N. Lingaya, J. Cordeau, G. Desaulniers, et al., Transportation Research Part B: Methodological **36(9)**, 755–778 (2002) DOI: 10.1016/S0191-2615(01)00027-3.
9. D. Butunov, S. Buriyev, S. Abdukodirov, et al., E3S Web of Conferences **389**, 05026 (2023)
10. J. Nong, L. Ji, Y. L. Ye, Z. J. Liu, China Railway Scientific **29**, 115–121 (2008)
11. D. Y. Levin, World Transport **4(71)**, 178-192 (2017)
12. N. Aripov, S. Suyunbaev, F. Azizov, A. Bashirova, E3S Web of Conferences **264**, 05048 (2021) DOI: https://doi.org/10.1051/e3sconf/202126405048.
13. S. Jumayev, S. Khudayberganov, O. Achilov, M. Allamuratova E3S Web of Conferences **264**, 05022 (2021) DOI: https://doi.org/10.1051/e3sconf/202126405022.
14. S. Suyunbayev, U. Khusenov, S. Khudayberganov, et al., E3S Web of Conferences **365**, 05011 DOI: https://doi.org/10.1051/e3sconf/202336505011
15. N. Aripov, S. Suyunbayev, M. Khadjimukhametova, S. Jumayev, Technology of shunting operations to divide a group of Wagons in the freight train into two directions. AIP Conference Proceedings **2612(1)** (2023)
16. B. S. Ertaevna, I. B. Malgaghdarovna, A. Z. Zhaksybaeva, S. S. Mansuraliyevich, Journal of Advanced Research in Dynamical and Control Systems **12(S6)**, 706-712 (2020) DOI: 10.5373/JARDCS/V12SP6/SP20201084
17. D. B. Baxodirovich, S. K. Kobiljonovich, S. S. Mansuralievich, European Journal of Molecular & Clinical Medicine **7(2)**, 277-290 (2020) https://ejmcm.com/article_2070.html
18. X. Xiang, X. Zhu, Journal of Transportation Engineering **142(3)**, 3–17 (2016)
19. Metodicheskie ukazaniya po raschetu norm vremeni na manevrovie raboti, vipolnyaemie na jeleznodorojnom transporte (MPS RF, Moscow, 1998)