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STRENGTHENING THE 19-KILOMETER TUNNEL

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In accordance with the Resolution of the Government of the Republic of Uzbekistan No. PP-1985, the construction of the Angren - Pap railway began in 2013. The project was developed taking into account the most complex engineering and topographical conditions, and in 2016 the railway line was put into operation. In the project documentation, there is a large project for the construction of a 19-kilometer tunnel. The project provides not only for the railway connection of the Fergana Valley with the rest of the territory of the Republic of Uzbekistan, but also for the shortest possible paths for the economic interaction of the territories of Western China with South Asia. However, plans to connect Western China with the countries of South Asia were postponed indefinitely due to a number of reasons.

At this moment, the solution to the issue of connecting Western China with South Asia is once again becoming relevant due to the revision of the reasons why the connection of these two important territories was suspended. The implementation of plans to connect Western China with the countries of South Asia along the Angren - Pap line may lead to a significant increase in the volume of transportation. However, the situation with the volumes of transportation in the first 5 - 15 years under the condition of the operation of the Angren - Pap railway line and the 19-kilometer tunnel located within it is very uncertain.

It is known that the amount of initial investments for the construction of railways, the timing of subsequent reconstruction measures to strengthen the line's capacity, as well as operating costs, largely depend on the size and growth dynamics of transportation volumes.

Strengthening the tunnel's capacity (construction of a second tunnel) to switch transit cargo flows between China and Central and South Asia requires significant additional investments and the involvement of foreign specialists. In addition, the Angren-Pap railway is located in mountainous conditions, which creates great difficulties in constructing a 19-kilometer tunnel in such conditions and entails large operating costs. It is precisely in such complex conditions that an analysis of uncertainties and risks is required when justifying the strengthening of the Angren-Pap railway line's capacity to switch transit cargo flows between China and Central and South Asia, and in particular, when assessing the strengthening of the 19-kilometer tunnel. Correctly assessing the risks will allow for saving construction and operating costs and increasing competitiveness with alternative modes of transport.

The projected freight flow through railways between China and Central and South Asia for 2020 is 7.24 million tons, for 2025 - 8.58 million tons, and for 2031 - 10.72 million tons [1].

According to the project, it is planned to carry out cargo transportation on the Sardala station - Razyezd 2 section in the amount of 21 pairs of trains per day [2]. It is clear that increasing the capacity of the Sardala - Razyezd 2 junction is necessary when switching transit cargo flows between China and Central and South Asia. Increasing the capacity of the Sardala - Razyezd 2 section is both complex and expensive in the future.

To organize a continuous intersection, a two-track section of a sufficiently long distance (at least 4-5 km) is necessary, which requires significant capital investments. Therefore, the introduction of a stopless intersection is generally carried out as a step in strengthening the capacity of a single-track railway as traffic volume increases. In this case, along with two-track sections formed by extending one of the station tracks, as a rule, two-track stations are built to significantly increase the line's throughput capacity (Figure 1).

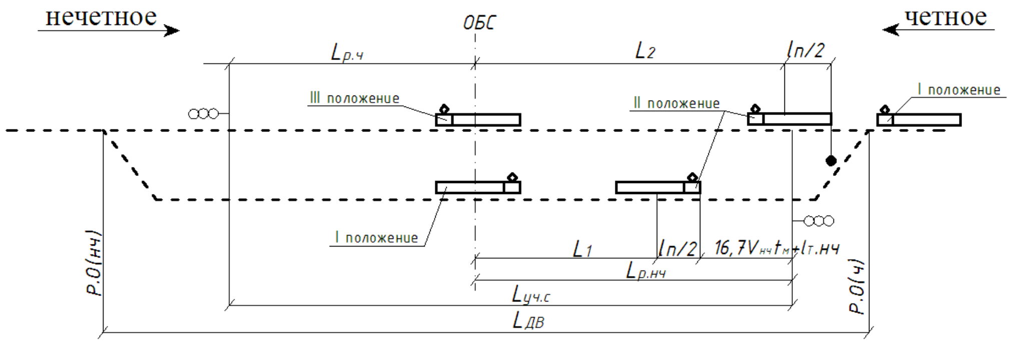

Figure 1 - Diagram of the section of continuous crossover of trains on the section

The introduction of a stopless crossing of trains allows for a 1.5 ÷ 1.7 times increase in the section's capacity and a 40 ÷ 60% increase in the section's speed [3], thereby reducing the required number of locomotives, wagons, locomotive crews, etc.

Below, an analytical method for determining the length of a two-track section of a continuous crossover of trains is considered.

As can be seen from Figure 1, when calculating the length of the intersection section (Luch.s), three positions of trains are fixed:

I position - the moment when the middle of the odd train is on the axis of continuous crossing (OBS), and the even train has not yet entered the crossing section;

Position II - the tail of the paired train is beyond the limiting column of the input arrow and has not reached the isolating junction, i.e., has not released the runway. At this moment, the head of the odd-numbered train must be at a distance equal to the braking distance $l_{t.nch}$, taking into account the additional distance (l_{dop}), equivalent to the time required to establish the route and open the output signal, i.e., $l_{dop} = 16{,}7V_{nch} \cdot t_m + l_{t.nch}$; where tm is the route preparation time, $l_{t.nch}$ is the braking distance of the odd-numbered train (determined by traction calculations);

Position III is the moment when the middle of a pair of trains is on the OBS.

From the above, it is clear that during the time period from position I to position II, the odd train travels the distance L_1:

$$L_1 = L_{r.nch} - \left(\frac{t_m}{2} + 16{,}7V_{nch} \cdot t_m + l_{t.nch}\right), \text{m}$$

where V_{nch} - speed of an odd train from the axis of a continuous intersection to the exit traffic light, km/h;

t_m - route formation time (with auto-blocking, it is 0.2 ÷ 0.3 min);

$l_{t.nch}$ - estimated braking distance;

V_{nch} - speed of an odd train from the axis of the continuous intersection to the exit traffic light, km/h;

$V_{vx.ch}$ - the speed of the paired train entering the OBS section, km/h.

Time spent, min:

$$t_1 = \frac{L_1}{16{,}7 \cdot V_{nch}}, min$$

If we denote the train travel time between positions II and III as t_2, min, and assume that the limiting column of the input pointer and the output signal are located in the same section, we obtain:

$$t_2 = \frac{L_2}{16{,}7 \cdot V_{vx.ch}} = \frac{L_{r.nch} - \frac{l_p}{2}}{16{,}7 \cdot V_{vx.ch}}, min$$

The sum (t_1+t_2), min, characterizes the magnitude of the different arrival times of trains:

$$t_{razn} = t_1 + t_2 = \frac{L_{r.nch} - (\frac{l_p}{2} + 16{,}7 \cdot V_{nch} \cdot t_m + l_{t.nch})}{16{,}7 \cdot V_{nch}} + \frac{L_{r.nch} - \frac{l_p}{2}}{16{,}7 \cdot V_{nch}}, min$$

Solving the obtained equation in relation to $L_{r.nch}$, we have:

$$L_{r.nch} = \frac{l_p}{2} + \frac{16{,}7(t_{razn} + t_m)V_{nch} \cdot V_{vx.ch} + l_{t.nch} \cdot V_{vx.ch}}{V_{nch} + V_{vx.ch}}, m$$

and $L_{r.ch}$ is determined by formula:

$$L_{r.ch} = \frac{l_p}{2} + \frac{16{,}7(t_{razn} + t_m)V_{ch} \cdot V_{vx.ch} + l_{t.nch} \cdot V_{vx.ch}}{V_{nch} + V_{vx.ch}}, \text{m}$$

Cross section length (distance between output signals):

$$L_{uch.s} = L_{r.nch} + L_{r.ch}, \text{ m},$$

and the total length of the two-way insert, taking into account the lengths of the throats:

$$L_{DV} = L_{uch.s} + L_g, \text{m}$$

where l_n is the length of the train, m;

OBS - axis of continuous intersection;

L_1 - distance between the I and II positions of a train moving in an odd direction;

L_2 - distance between the II and III positions of a train moving in a paired direction;

$L_{uch.s}$ - length of the section of continuous intersection of trains of even and odd directions;

L_{DV} - total length of the double-track insert, taking into account the throats;

RO (nch), RO (ch) - calculated axes (beginning) of a two-track section of odd and even directions;

$L_{r.ch}$, $L_{r.nch}$ - the distance from the stopless intersection axis to the output signal in even and odd directions.

Below are the proposed measures to enhance the interest-based route.

The distance from the axis of the continuous intersection to the output signal in the even and odd directions at the Sardala - Razyezd 2 junction is determined by formulas:

$$L_{r.nch} = \frac{651}{2} + \frac{16{,}7(3+0{,}2)\cdot 50\cdot 40 + 1200\cdot 40}{50+40} = 2046{,}4\ m;$$

$$L_{r.ch} = \frac{651}{2} + \frac{16{,}7(3+0{,}2)\cdot 40\cdot 50 + 1200\cdot 50}{50+40} = 2179{,}7\ \mathrm{m};$$

The length of the cross section (the distance between the output signals) is determined by formula:

$$L_{uch.s}=2046{,}4+2179{,}7=4226{,}1\ \mathrm{m}$$

The length of the double-track insert, taking into account the lengths of the throats at the Sardala - Razyezd 2 junction, is determined by formula (8).

$$L_{DV} = 4226{,}1 + 2\cdot 39{,}063 = 4304{,}23\ \mathrm{m}$$

It is necessary to lay the second track on the section of a continuous intersection of trains, two turnouts.

Figure 2 shows the final results for increasing the power of the Sardala - 2nd junction.

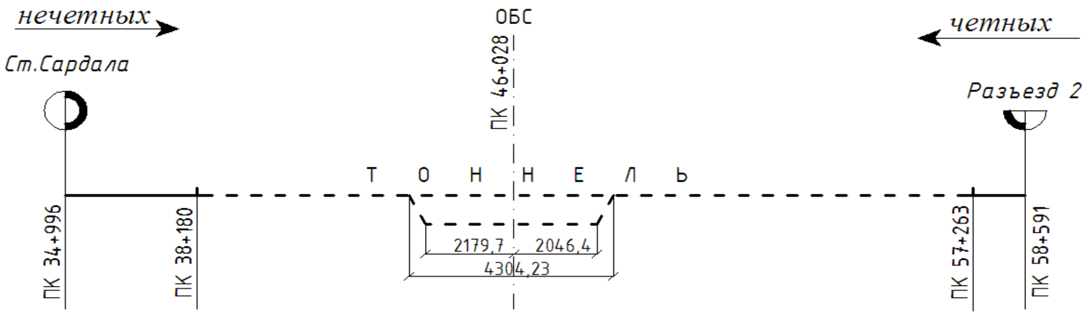

Figure 2 - Results of power reinforcement of the Sardala pass - 2nd junction

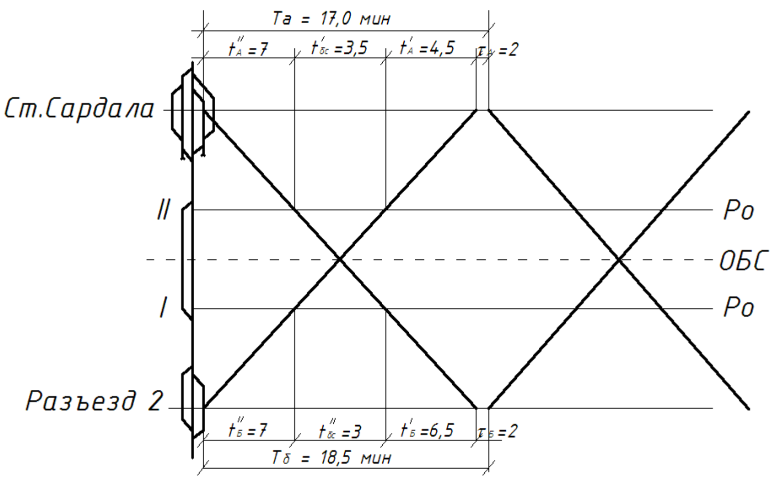

Figure 3 - Organization of train traffic with a double-track insert on the section of the Sardala station - 2nd junction

As shown in Figure 3, if there is a two-way insert on the Sardala - Razyezd 2 junction that allows for the continuous intersection of trains, the junction's capacity can be determined using formula:

$$n = \frac{(1440 - t_{TEXN}) \cdot \alpha_n}{\text{T}_A + \text{T}_B},$$

$$n = \frac{(1440 - 90) \cdot 0{,}95}{17{,}0 + 18{,}5} = 36\ (\text{pair of trains})/\text{day}$$

where t_{TEXN} – is the technological window, based on static data, t_{TEXN} is assumed to be equal to 90 min on single-track lines; α_n – is the reliability coefficient, taking into account rolling stock failures. In general, the reliability coefficient when calculating the available throughput capacity is taken for electrified single-track lines at 0.95; t'_{A}, t''_{A}, τ'_{bs} - the travel time of odd and even trains between the Sardal station and the double-track insert and the interval of continuous crossing along the calculated axis I, min; t'_{B}, t''_{B}, τ''_{bs} - the travel time of odd and even trains between the 2nd junction and the double-track insert; τ'_{bs}, τ''_{bs} - and the interval of continuous intersection along the calculated axis I and II, min.

The number of freight trains on sections with predominant freight traffic is determined by formula (10):

$$n_{gr} = n - n_{ps} \cdot \varepsilon_{ps} - n_{sb}(\varepsilon_{sb} - 1),$$

$$n_{gr} = 36 - 2 \cdot 1{,}7 - 1 \cdot (1{,}8 - 1) = 32 \text{ pair of trains/day.}$$

where n – is the section capacity; ε_{ps}, ε_{sb} – is the discharge coefficient for passenger and combined freight trains; ε_{ns}= 1,7; ε_{sb} = 1,8; n_{ns}, n_{sb} – are the movement dimensions (trains, train pairs) of various categories; passenger and combined trains; n_{ns} = 2; n_{sb} = 1.

At the Sardala station - Razyezd 2 junction, the device of a double-track insert allows for the continuous intersection of trains, increasing the number of freight trains on the sections by 11 pairs per day.

Conclusion

Mastering transportation is envisioned at the Sardala - Raz.2 junction with the construction of a double-track extension. On this section, the construction of double-track crossings allows for the continuous intersection of trains and, consequently, increases the capacity of a single-track line. The project is the most cost-effective, as it requires less capital investment than construction at the second track junction. If the proposed measure is implemented during the implementation of the main project, it will be 20-25% more economically beneficial than the considered transportation in the future.

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