Study of Bypasses for High-speed Passenger Trains, as an Alternative to the Reconstruction of Railway Stations

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Abstract. Nowadays, in order to organize the movement of passenger trains with speeds up to 200 km/h, it is necessary to reconstruct existing highways, which requires the need, in addition to performing a huge amount of work, to do it "under wheels", i.e. in conditions of continuous movement, when it is often impossible to take trains to other routes (parallel passages), due to the lack of the last ones. As an alternative, the authors propose to consider the principal possibility of using bypasses for the passage of high-speed passenger trains, which in practice are often used for the organization of transit freight traffic, both individual railway stations and railway junctions in general. This allows not only to remove obstacles ("barrier places") on the way of train traffic, but also to "unload" the existing infrastructure of railway stations and nodes. For this purpose, at the first stage, the factors that can affect the feasibility of using bypasses to perform such a task as the organization of high-speed passenger train passes were considered. The article can be useful for specialists, researchers who are engaged in the solution of issues on the organization of high-speed passenger traffic in terms of the preparation of existing highways in general, and railway stations in particular.

1. Introduction
Historically, speed increases in the passenger segment of railway transportation in our country happened and is happening with the development of high-speed (up to 200km per hour) traffic [1]. The existing length of highways does not allow domestic railways approach world leaders yet [2], indicating the undoubted relevance of research. The main problem with the introduction of high-speed traffic is that the reconstruction of existing separate points with track development is required, which is quite expensive from a financial point of view, primarily because of their large number. In addition, as a result of possible travel development schemes variety due to local conditions of various nature, the reconstruction often requires huge costs, and even the reduce of the performed speed level.

In these conditions, it makes sense to investigate the possibility of providing an increase in speeds in a different way. This study is devoted to the rationale for a bypass line building as an alternative to the reconstruction of separate points with track development under high-speed passenger traffic (more than 140 and up to 200 km per hour), for which at the initial stage it is necessary to consider factors indicating the appropriateness of the proposed events in comparison with the reconstruction.

2. Problem statement
Bypasses are designed to perform various tasks, but most often they are used to organize the passage of transit trains, moreover, on domestic railways – mainly freight ones [3, 4, 5, 6]. Overseas bypasses
are also used [7, 8, 9, 10, 11], also for the removal of passenger traffic, a typical example is a bypass of a Paris railroad junction, connecting north and south, which allowed to increase the promotion of high-speed trains [12].

Of the total number of factors that are inherent in the rounds in general [13], we note the construction one, consisting of the absence of work on the necks reconstruction, which may require significant work on the dismantling of tracks, turnouts, construction transitions at different levels and others depending on the conversion scheme, which are given in detail in the research [14, 15].

In addition, the operational factor, reflecting the degree of convenience of work performance during breaks in movement – "gaps", and also the influence of this process on the ongoing work of the section [16, 17, 18].

During the construction of a bypass the breaks in operation are required when connected to the main line by turnouts. The operational factor also includes accounting for mileage of high-speed passenger trains, which can both increase and decrease depending on the position of a separate point with track development on the highway.

In this regard, it should be noted that, firstly, the construction of bypasses of separate points with track development can only be considered if there are no passenger high-speed trains stops on them, for boarding and disembarking passengers. Otherwise, significant reconstruction is not required, moreover, during the construction of the bypass it will be necessary to solve the problem on the delivery of passengers to the existing separate point.

Secondly, the bypass of a single operate point, not likely to be appropriate, except for the case when the route straightens due to the loss of benefits from the acceleration, because it will require the reduced train speed at the points of their exit (entry) to the bypass when the deviation turnouts. The use of switches of very flat marks, as it is done in some countries [19, 20], is quite expensive and requires careful justification.

To determine the influence of the length of the bypass line, the question of its position relative to the separate point with the track development is of interest. The authors give possible, in their opinion, schemes of mutual placement of the existing infrastructure and the supposed bypass (fig. 1), from which it can be seen that the bypass line, depending on local conditions, can be placed on the following options for separate points with track development:

- with an enveloping arrangement (fig. 1, a), the variant is typical when placing main routes, for example, at marshalling yards;
- one-way bypass placement (fig. 1, b and fig. 1, c).

**Figure. 1** The scheme of the railway section and the bypass line used for the high-speed passenger trains a – vast arrangement of bypass routes; b – one-sided enclosing arrangement of detours; c – rectifying position of detours; A1, A2, Ai – separate points with track development; Lbyp, Lrec – the length of the bypass and the area of the location of separate points with track development respectively.
In the first variant (see fig. 1, a), it is proposed to reject high-speed trains along turnouts on the main tracks without going through the neck of the station, while the length of detours will increase.

In the second variant (see fig. 1, b), high-speed passenger trains deviate by one from the main bypasses on overpasses, on the other ones – on turnout switches.

The third variant (see fig. 1, c) differs from the second one that the bypass line is rectifying, decreasing the travel distance of high-speed passenger trains.

The condition for the feasibility of detour constructing (economic factor), in comparison with reconstruction for high-speed passenger traffic, can be written down in the following way:

$$\sum K_{by} \leq \sum K_{rec}$$  \hspace{1cm} (1)

where $K_{by}$, $K_{rec}$ – capital investments, respectively, into the bypass construction and line reconstruction, million rubles.

In this case, the following condition must be satisfied

$$t_{by} \leq t_{rec}$$  \hspace{1cm} (2)

where $t_{by}$, $t_{rec}$ – passenger train travel time on the line, respectively, at the bypass construction and after the reconstruction of an existing line, min.

**3. Summary**

To determine the composition and volume of capital investments required for the bypass line construction and reconstruction of the existing line for high-speed passenger traffic, you can use the appropriate theoretical developments with some amendments due to the fact that by rounds there will be carried out not freight, but passenger traffic, and even with increased speeds. In this case, it should be kept in mind that the following facts are important:

- the level of the speed of passenger trains planned for the implementation, which in version with a bypass line may be larger, due to the absence of restrictions in the form of curved sections of tracks, turnouts, structures, etc.;
- the length of the bypass line, which may be both longer than the existing route of passenger trains, or shorter, depending on the route construction variant;
- the higher is the feasibility of the bypass option, the greater is the volume of reconstructive work and costs for the conversion of a separate point.

Thus, further authors’ researches will be aimed at determining the feasibility of a bypass line constructing, depending on its length, level of realizable speed, kind of conversion, initial power level of the existing infrastructure.

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