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Impact ways of limiting train traffic for the duration of subgrade works

Abstract: The article contains the results of the analysis of the method of limiting train traffic for the duration of the reconstruction of the subgrade based on the experience of modernization of the fragment of the railway line No. 6. Described the track closures types influencing the scale of train movement limitation, used in the repair and modernization subgrade works. Presented the conditions of conducting works at each type of closures.

Keywords: Subgrade, Subgrade works; Track closures

Introduction

In the period of intensified repair and modernization works performed as part of the National Railway Program on the network of railway lines in Poland, investments on two- and multi-track lines are carried out with a partial and total suspension of trains on reconstructed sections. In the first case, the line is passable, robots are made in unfavorable conditions, and the trains are run with some difficulties and limitations. In the second case, when the works are carried out with a complete stoppage of traffic, there are significant difficulties in passenger traffic and a significant reduction in the railway network capacity for freight traffic. For the continuity of traffic, it is required to route goods and long-distance trains along traveling lines and to apply substitute bus communication in local passenger traffic. However, the complete closure of line segments is to facilitate the work of contractors, enable better inter-branch coordination of works and significantly shorten the time of investment implementation. The selection of the method of carrying out works depends on many factors, the most important of which are: the possibility of routing trains on the traveling lines, the favorable road network for the possibility of conducting bus transport, the length of the modernized line sections, the scope of works, availability of building materials and technical means.

In the history of modernization of railway lines in Poland, the first case of stopping traffic on the two-track line during the works took place on the fragment of railway line No. 6, which is the first Pan-European corridor E-75, on the section Tłuszcz - Łochów with a length of 18 km. During the construction works in the single-track closure mode, the Administrator

decided to completely close the line for train traffic and introduce substitute bus communication in passenger traffic and to conduct freight traffic along the traveling lines. According to the assumption of the Employer, such solution was to shorten the time of investment implementation by 10 months. The purpose of the modernization of the line No. 6 on the section Tłuszcz - Łochów was to improve its technical condition, in accordance with the requirements of international agreements, enabling the trains to increase speed up to 160km / h in passenger traffic and up to 120km / h in freight traffic. The reconstruction consisted of, among others on replacing the track surface and reinforcing the track bed. The new pavement construction consists of 60E1 rails, PS-93 sleepers, and ballast. Strengthening the subgrade included appropriate preparation of the ground consisting of on soil stabilization with hydraulic binders and the incorporation of a protective layer. During the 25 months of construction, 36 km of a single track was built, 10 platforms and some of the level crossings with car roads were replaced with non-collision intersections [4].

The specific way of carrying out works on the indicated section of railway line No. 6 made it possible to conduct a comparative analysis of two modes of work implementation at partial and total stopping of traffic and to determine the impact of the method of limiting train traffic for the time of reconstruction of the subgrade.

Types of closures used in subgrade works

Subgrade works, depending on the scope and technology of their execution, on double-track lines may be carried out with a partial or total suspension of train traffic using the following organizational assumptions:

- implementation of works at the speed limitation of trains without the need to enter track closures,
- closing one of the tracks in intervals between trains set in the timetable,
- closing one of the tracks for train movement and running trains on the second active track in both directions (single-track closure),
- closure of both tracks during works causing a break in train traffic (two-way closure) [1, 3].

Single-track closures are the most common practice when carrying out works requiring due to their range of train movement stoppage. This is confirmed by the fact that in the years 2013-2015, on two-track lines, construction works as part of repairs and modernizations were mainly conducted during single-track closures [2]. With a single-track closure during the construction process, the trains can be run in two directions on the active track, the line is passable and the inconvenience for passengers is minimized.

Two-way closures are used sporadically, above all in the implementation of investments with a large range of works, a considerable length of rebuilt sections and when the execution time must be as short as possible. When the train traffic is completely stopped, there is a considerable impediment to passenger traffic and a significant reduction in the railway network capacity for freight traffic. In order to maintain the continuity of traffic, freight and long-distance passenger trains are routed along the traveling lines and in the local passenger traffic a substitute bus communication is used.

Conditions of carrying out works depending on the type of closure

The main factor determining the manner, pace and safety of the repair or modernization works on the subgrade is the way in which trains are limited during their lifetime. Preservation or suspension of train traffic during construction processes results in various implementation conditions.

Regardless of the type of track closures used to reduce their number and duration, the work should be properly coordinated and carried out with possibly the greatest concentration

of forces and technical means [1]. When organizing and carrying out works, one should take into account, among others type and scope of works, duration of the closure, length of sections to be closed, length of works for individual work teams, machines and mechanical equipment [3], transport of materials within the works performed.

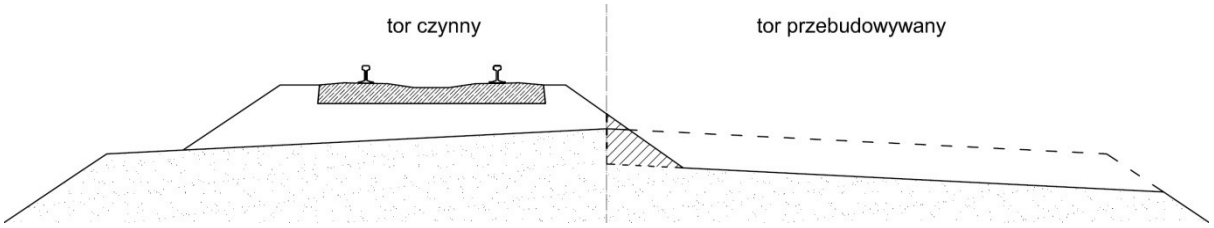
Implementation of the reinforcements of the track bed by incorporating protective layers into its upper zone is associated with the execution of earthworks with significant volumes. It results from the necessity of loosening the subgrade soil for the possibility of laying the layers of the required thickness and the incorporation of materials and aggregates necessary to obtain layers of the designed structure. Occurring significant volumes of earthworks require the use of the appropriate type and number of transports means necessary to carry out the task. The choice of the type of means of transport also depends on the method of limiting train traffic during the work.

Single-track closures

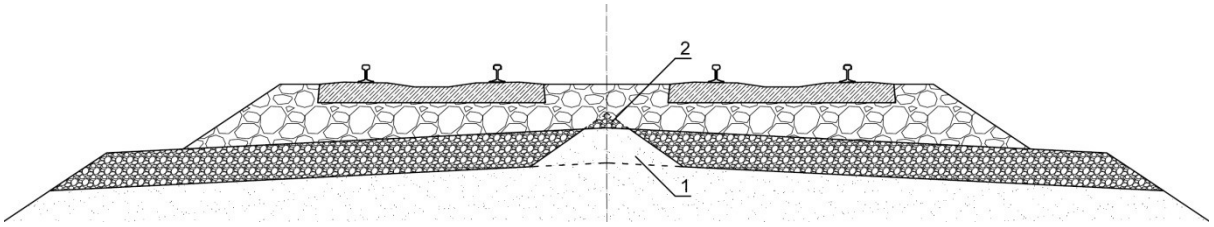
When performing work on single-track closures, special care must be taken in the vicinity of the live track and live traction network. Depending on the method of securing the place of works, their implementation, while maintaining the continuity of train traffic, may require supervision of whistleblowers that take care of the traffic safety of trains and employees working in the track. For safety reasons, employees should exercise extreme caution, especially during train journeys, and construction machinery operators should, moreover, remember to keep the gauge of the active track from moving parts of operated machines, as well as to suspend machine operation for the time the train travels on the active track. The speed of trains should be reduced on the active track, especially when heavy tracked machines are used in the reconstructed track. The experience of people responsible for the safety of work of people and equipment at the construction site shows that every time the implementation of a new operator of construction machinery to work within the active tracks, despite training in occupational safety and health entails the risk of an increased risk or accident.

Under favorable conditions, during the implementation of subgrade works, during single-track closures, the export of spoil from the construction site is usually carried out with the use of trucks, and the supply of aggregates for protective layers using hoppers moving on the adjacent, active track in intervals set in the timetable between trains. In the case of work especially in deep and relatively long excavations, the use of trucks for the extraction of spoil is associated with a significant reduction in productivity and length of work due to the lack of opportunity to organize the passages. In this case, it is more beneficial to use for transporting the spoil of the railway transport taking place on the adjacent track in the intervals between successive trains set in the timetable. When works are carried out on the lines, the importance of traffic ladders, the set intervals between trains are short and usually only take a few hours a day, especially at night. Such short closures of the active track are often insufficient for the performance of works with the assumed efficiency. In the case of the reconstruction of the subgrade made on the route of considerable length, delivery of materials to the protective layer by railway transport on the active track during the interval between trains, especially when the construction site is located on the only end of the reconstructed section, faces considerable difficulties. They result from the need to travel long distances by a working train moving at a very low speed. In this way, the break time between successive scheduled trains, mainly, is used to drive the work train to the destination unloading site and its return to the home station. The remaining time from the interval between trains may be insufficient for the discharge of the necessary, in order to preserve the assumed capacity, the volume of materials constructed protective layers.

During the construction of the protective layers of the track bed during single-track closure, it is often a situation in which it is difficult or impossible to build a protective layer with a designed structure in the vicinity of the track axis. This problem occurs primarily with track gauges not exceeding 4.0 m [4]. During the execution of works, the removal of too much ballast from the front of the active track sleepers may lead to a violation of its stability, and in extremely unfavorable conditions even to its buckling. It is, therefore, necessary to leave the undisturbed fragment of the track under the reconstructed track (Figure 1). Therefore, in the vicinity of the track axis, there remains an area where the protective layer is of a different design than the one designed or even does not exist (Figure 2). In the case of comprehensive repair of the track bed under two tracks and execution of works separately under each track, the area of the existing ballast with a width of approximately 0.3 to 0.4 m (Figure 2) may remain intact in the track axis, which may have a negative impact by reducing permeability of the ballast, to the condition of tracks during later exploitation. The above problems can be minimized by using additional technical solutions, which, however, increases the cost and extends the duration of works.



1. Limitation of the possibility of reconstruction of the subgrade along the whole track width in the mode of single-track closures resulting from the need to maintain the stability of the active track. The area of ballast and subgrade not subject to replacement was marked



2. The shape of the protective layer of the subgrade obtained after rebuilding carried out in the mode of single-track closures. 1 - Area of lack of protective layer. 2 - Area of the intact existing ballast

Two-way closures

The implementation of works on a double-track closure minimizes the risk of occurrence of events resulting from the presence in the vicinity of the reconstructed subgrade of an active track on which increased train traffic takes place. On the construction site, there is a movement of work trains traveling at a limited speed and therefore characterized by a short braking distance. With appropriate supervision over the passage of work trains, the risk of occurrence is minimized, and in the event of their occurrence, losses are minor.

Conducting works on a double-circuit closure gives the contractor greater freedom to carry out the works. Inter-branch coordination is greatly facilitated, and it is possible to perform works in parallel on neighboring tracks. With a single-track closure, it is practically necessary to do all the work in the track before making it available for the operation of the

network industry. This is caused by the occupation of the track, usually on the entire stretch, with no possibility of maneuvering between network trains. With the possibility of using both tracks, it is possible to do the works on the assumption that each industry chooses one of them. This greatly speeds up the work, and with good coordination, it is possible to do both industries almost simultaneously [4].

One of the biggest advantages of carrying out the reconstruction of the track bed during the double-track closure is the possibility of using one of the tracks for transporting the spoil and transporting the materials of protective layers at any time. In this case, the limitation of the efficiency of works may be affected by the availability of storage sites for spoil and building materials and the efficiency of handling equipment.

During the construction works at the time of the two-story closure, the reconstruction of engineering facilities takes place immediately under two tracks. If there are several large engineering objects on the reconstructed section of the line, it may hinder or even make it impossible to transport materials with the use of rail transport.

In a two-way closure, it is possible to carry out track work with greater accuracy, e.g. by correctly making connections of the protective substructure of the subgrade and the surface of both tracks along the track axis. Depending on the technology of the works, this problem is solved differently. In the case of the reconstruction of each track, it is possible to start earthworks and build a protective layer in the neighboring track after the ballast subbase is made and the foundations and rails are laid on it in one of the tracks. With this way of carrying out the work, it is possible to connect the substructure elements, protective layers and ballast subgrade in both tracks appropriately.

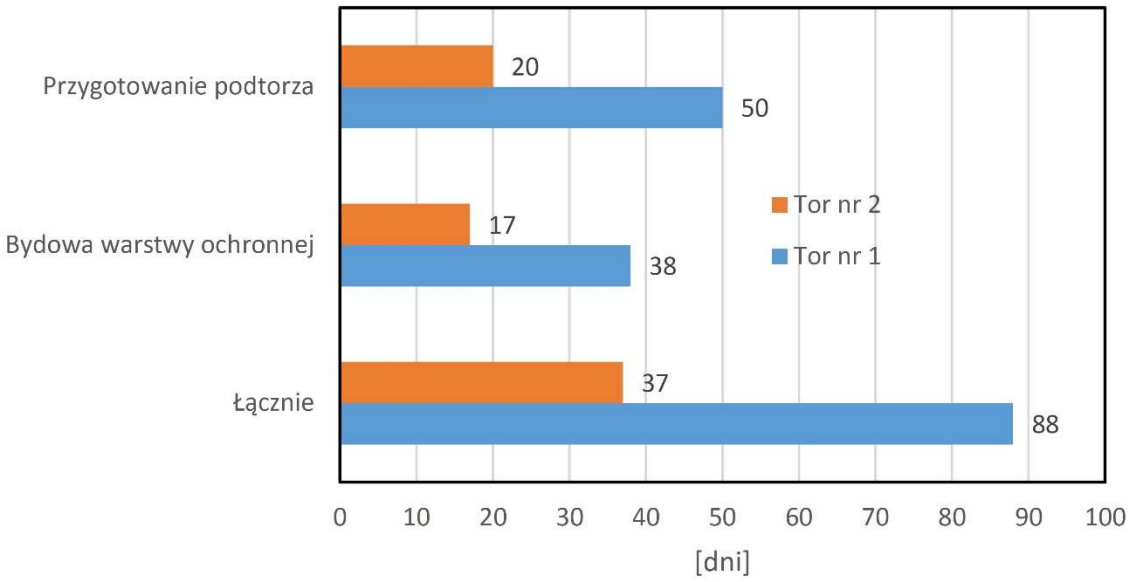
The impact of the type of closures on the time of subgrade works

The impact of the method of limiting train traffic for the duration of works was analyzed on the basis of experience gained from the reconstruction of the 18 km section of railway line No. 6 [4]. The reconstruction was carried out with one- and two-way closures. Track No. 1 was rebuilt in single-track closures. Track No. 2 has been rebuilt in double-track mode. Performing the same works, in one episode, with two different track closure modes, given the opportunity to assess the impact of the type of track closure method used for the performance of the reconstruction of the subgrade of the analyzed section of the railway line.

The preparation of the subgrade consisting in the selection of the upper layer of the subgrade with an adequate thickness, to enable the construction of the protective layer with the designed structure, was performed in both tracks by work teams consisting of workers and excavators, bulldozers and trucks. If necessary, the track bed was strengthened by replacing the ground or cement stabilization. For the export of spoil during the preparation of the track no. 2 there was also used railway transport, which took place on an adjacent track [4].

The construction of the protective layer took place with the supply of aggregate by means of rail transport on an adjacent track and from work teams consisting of workers, excavators, bulldozers and rollers [4].In track No. 1, the preparation of the subgrade and the construction of the protective layer was much slower than in track 2. The reason for this was primarily the limited possibility of using an adjacent active track for transporting loose soil and aggregates protective layers. In a single-track closing mode, the adjacent track was available only during a single 3-hour closure per day. In a two-way mode, the contractor had unlimited access to the adjacent track. It follows that during the sub-rail works carried out, the efficiency of the transport means had a decisive impact on the total time of completing the task [4].

Figure 3 shows and compares the implementation times for individual reconstruction activities of track subgrade No. 1 and 2 on the analyzed section of railway line No. 6.



3. The time of carrying out the subgrade works during the reconstruction of tracks No. 1 and 2 on the analyzed section of the railway line No. 6

The time of carrying out work involving the preparation of the subgrade and the construction of the protective layer during the sub-track works in track No. 1, in the mode of single-track closures, amounted to a total of 88 days. During the 50 days, earthworks were carried out, and 38 days were needed to build a protective layer. The completion time of similar work on the reconstruction of Track No. 2 subgrade was 37 days in total. During 20 days, earthworks were carried out and 17 days were needed to build a protective layer [4]. Unrestricted access to the neighboring active track in the double-track mode allowed to shorten the time of carrying out earthworks 2.5 times, and the time of implementation of the protective layer 2.2 times. The total time of reinforcing the track bed thanks to the implementation of works in the double-track mode was nearly 2.4 times shorter. While carrying out the work while maintaining the continuity of trains on the adjacent track, the work efficiency of the track bed preparation about 360 mb/day and the construction of a protective layer around 475 m/day was obtained. During the implementation of works after the suspension of train traffic, the efficiency of the preparation of the 900 mb/day bedstead and the construction of a protective layer of approximately 1050 m / day were obtained.

Summary and Conclusions

The impact of the method of limiting train traffic for the duration of subgrade works was analyzed on the basis of experience from the reconstruction of a selected section of railway line No. 6. Works were carried out in specific terrain-organizational conditions determining, among others, the technology used and the number and composition of work teams. For this reason, it is not possible to directly apply the shortening of the subgrade works time achieved here, as a result of the implementation of the double-track closure, to other cases. The total duration of works is influenced by many factors, and the manner of restricting train traffic during the construction process is just one of them. In other terrain and organizational conditions, the influence of the type of track closures used for the duration of the works could be different. Therefore, it is advisable to conduct further research on the influence of the type of track closures used for the duration of works.

On the basis of the analysis of the influence of the type of track closures on the time of the reconstruction of the subgrade on the example of modernization of the fragment of the railway line No. 6, the following conclusions can be made:

- The decision on partial or total closure of a line should be made taking into account the type, scope and planned time of planned works as well as the scale of disruptions in passenger and freight traffic occurring during the implementation of the works.
- Performing repair and modernization works of the subgrade in the double-track mode allows, among others, to maintain greater safety of works, obtain greater accuracy of works, better inter-branch coordination of works and significantly shorten the time of investment implementation.
- The ability to freely dispose of the use of an adjacent track by the contractor while carrying out the work has a decisive impact on the time of sub-contract work.
- The duration of the works, consisting in the preparation of the subgrade and the construction of the protective layer, on the analyzed section, was almost 2.4 times shorter in the double-track mode since the same works were performed in single-stop mode.

Source materials

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