Development Opportunities for Public Transport Facilities in the Wroclaw Agglomeration on Selected Examples

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The construction of passenger stops of the railway transport has been proposed in order to operate the communication infrastructure of two housing complexes – the village of Mirków and the Residential Estate 'the Four Seasons' *(Polish: 'Cztery Pory Roku')*, belonging to the agglomeration of Wroclaw. The possibility of the location of the stops within the existing infrastructure is considered. There are presented several variants of the solution to the track layout with passenger service facilities (platforms). The parameters are provided to use for the proposed railroad turnouts and the track pavement structure. In the case of the Estate 'Four Seasons' there are also discussed the conditions for the construction of the tram route enabling communication with the center of Wroclaw. The concept of the tram loop in terms of the location of the estate area and the geometric layout of tracks is presented as well.

Keywords: rail transport, public transport, the Wroclaw agglomeration.

1. INTRODUCTION

The dynamic territorial development of the agglomeration of Wroclaw, inspired by the activity of medium and small-sized industries, generated the expansion of districts existing at the outskirts of Wroclaw with their residential resources and the potential for building new housing estates. In view of this continuing trend, persistently at the unflagging level since the groundbreaking date of the year 1989, the necessity for rapid and collision-free communication of these complexes with the city center is clearly visible.

The residential complex 'Four Seasons' stands out from among housing estates that emerged in the process of the socio-economic development of the city. In contrast, the example of a fast developing village is Mirków, which is situated on the border of the Wroclaw city and the municipality of Długołęka. In recent years, the relevant administrators have stepped out efforts to improve public transport in respect of both of the abovementioned locations.

The article presents the proposal for the construction of passenger stops of railway transport for handling these two residential complexes. In both cases there was indicated the location of the railway stop in the existing infrastructure, and proposed several variants of the arrangement of the track layout.

2. THE CONCEPT OF THE PUBLIC TRANSPORT RAIL STOP FOR THE VILLAGE OF MIRKÓW

2.1. THE LOCATION OF THE HOUSING ESTATE AND THE PROPOSED PASSENGER STOP AS WELL AS THE EXISTING INFRASTRUCTURE CONDITION

The village of Mirków is situated in the northeastern sector of the agglomeration of Wroclaw, near the border of the city, within Wroclawska, Kolejowa and Kiełczowska Streets, and belongs to the municipality of Długołęka (Figure 1) [13]. Kolejowa Street forms the southern border of the village-estate along which the double-track PKP Polish Railway Lines S.A. line No. 143 runs, thus connecting Wroclaw and Lubliniec, with a branch in Oleśnica in the direction of Warsaw via Łódź. The construction of a passenger stop along the railway line is justified by everyday significant stream of passengers heading towards the city of Wroclaw at morning peak hours, while at afternoon rush hours – the return flow.

Figure 1 shows the area crossed by the PKP railway route (delimited by Bierutowska and Kiełczowska Streets), where the possible location of a passenger stop would be possible, as the flat and fallow land [13]. The direct access from Bierutowska Street to the stop is not possible, as the street through a viaduct over the tracks of the railway line. Therefore, the location of the stop platforms at a distance of several meters from the intersection of the tracks with Kiełczowska Street seems rational in order to allow travelers to reach the Housing Estate, and go back. The crossroad of the tracks with this street is the railway level crossing, classified as A-level. One-level intersection enables the free, direct access by car from the Estate to the area of the planned passenger stop. The area located in the southern direction with respect to the railway station, adjacent to Kiełczowska Street is undeveloped; hence it qualifies for the construction of a car park, which could function in the Park & Ride system. The proposal for the location of the car park integrated with Kiełczowska Street as the primary access road artery and the planned passenger stop is illustrated in Figure 1 [13]. The presented logistics solution could constitute a mini interchange serving the eastern central Wroclaw agglomeration.

2.2. THE DESIGNED INFRASTRUCTURE OF THE PASSENGER STOP

The separate issue, independent of the location of the rail stop, is the railway infrastructure, including [1-3, 7, 10-13]: the geometrical track layout, the track drainage system, potential engineering structures (e.g. drainage culverts), the construction of platforms, the signaling system, any connections of the stop with suburban buses (pedestrian route, etc.) as well as horizontal and vertical road marking as part of the traffic organization on Kiełczowska and Kolejowa Streets, in the vicinity of the rail stop.

The solution for the rail stop infrastructure in respect of the track geometry layout is presented in five variants in Figures 2-9.

Variant I (Figure 2): the track layout of the PKP line (the first-category) remains unchanged, while there is envisaged the construction of two external one-edged platforms (min. 4.0 m wide) and the mesh fencing of the height of 1.10 m preventing passengers from direct crossing the tracks [7, 8, 10]. Passageways for pedestrians from

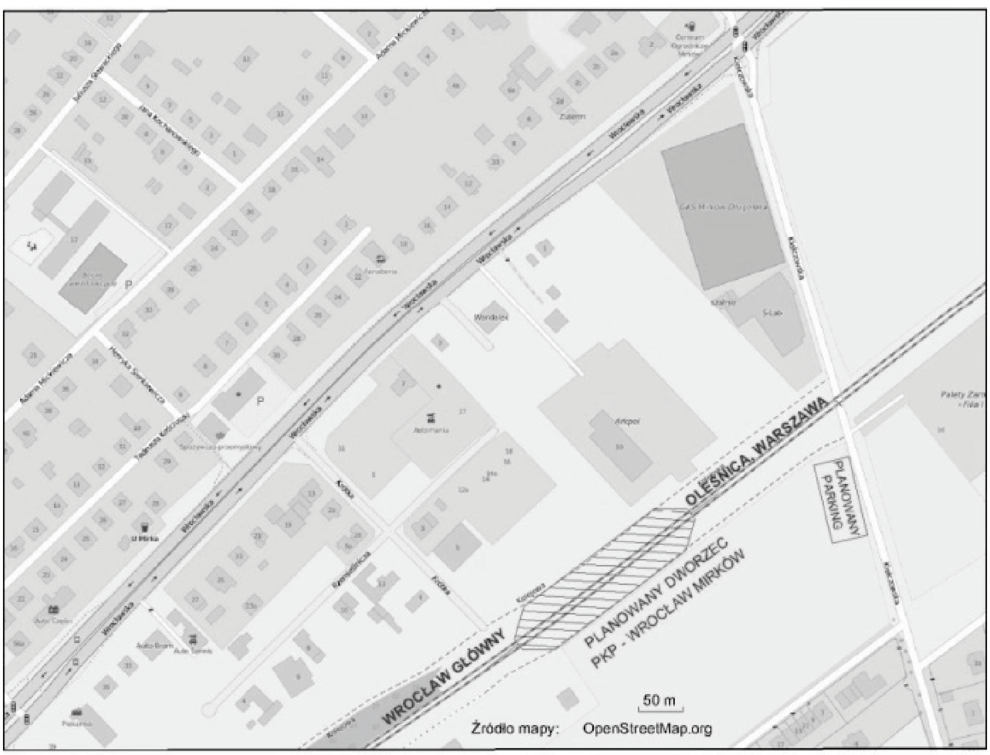

Fig. 1. The location of the village of Mirków and the flowchart of the proposed public transport stop in the line of PKP PLK S.A.
Source: own study based on [13].

the stop to Kolejowa Street lead by crossing the tracks at the rail level. This is the cheapest solution, but the capacity of two one-edged external platforms may prove insufficient.

Variant II (Figure 3) differs from the first one as the one-edged external platforms are shifted in relation to the pedestrian track crossing at the level of rails.

Variant III (Figure 4) provides for the construction of: two additional tracks No. 3 and No. 4, two trapezoidal connections of tracks at both ends of the stop (the connections of the tracks are performed with two ordinary turnouts and a straight insert); four one-edged platforms; 12 ordinary turnouts. Trapezoidal connections are proposed in order to allow the entry of the train on the wrong track, if such a need exists in the case when repair works are carried out on the railway line.

Variant IV (Figure 5) requires the construction of: two additional tracks No. 3 and No. 4, two trapezoidal track connections at both ends of the stop, and two two-edged platforms.

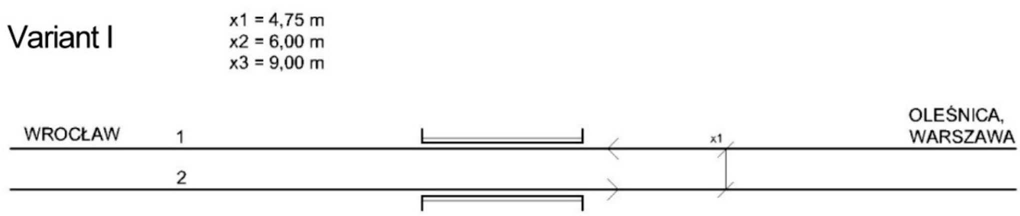

Fig. 2. Variant I of the construction of the track layout of the passenger stop.
Source: own study.

Fig. 3. Variant II of the track layout of the passenger stop.
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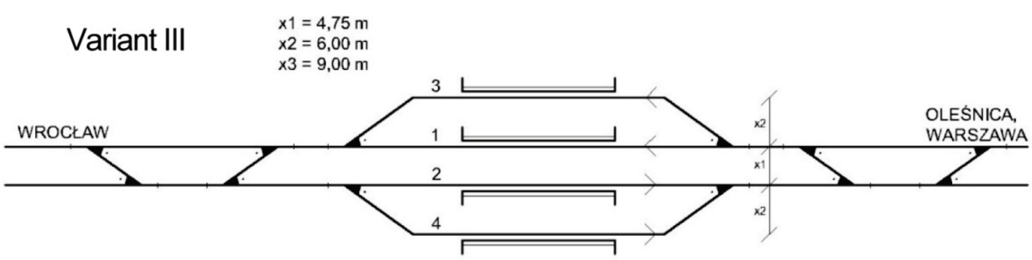

Fig. 4. Variant III of the track layout of the passenger stop.
Source: own study.

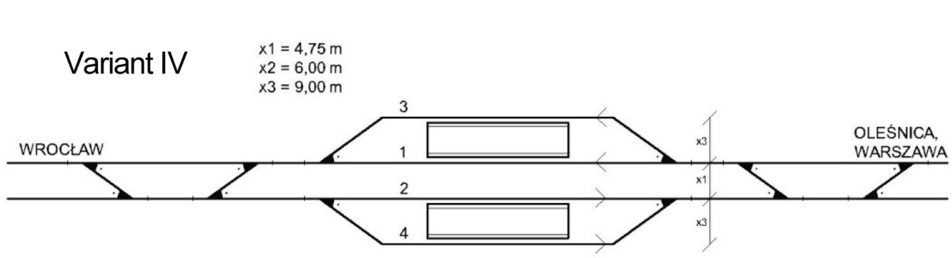

Fig. 5. Variant IV of the track layout of the passenger stop.
Source: own study.

Variant V (Figure 6) consist in constructing: four additional tracks No. 3, 4, 5 and 6; two trapezoidal track connections: two internal one–edged platforms (2.8 m wide) and two two-edged ones.

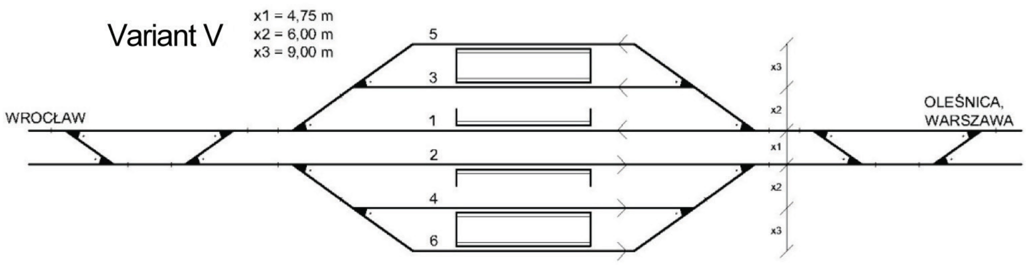

Fig. 6. Variant V of the track layout of the passenger stop.
Source: own study.

Variant VI (Figure 7) proposes: four additional lanes No. 3, 4, 5 and 6; two trapezoidal connections of tracks; two two-edged platforms and two external one-edged ones.

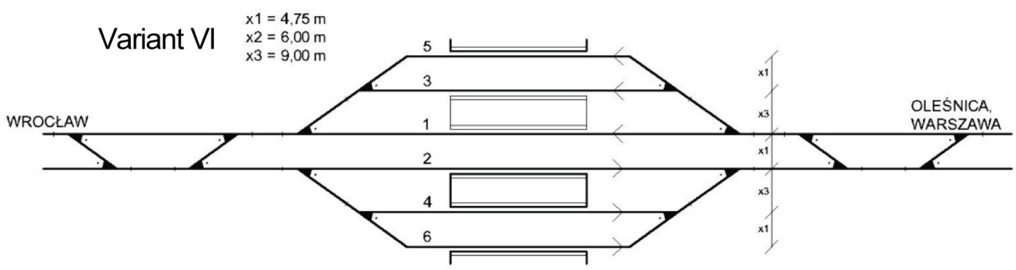

Fig. 7. Variant VI of the track layout of the passenger stop.
Source: own study.

Bearing in mind the minimum costs of reconstructing the existing I-ordinate two-track line, Variants I-VI do not provide for extending the axial spacing of tracks No. 1 and No. 2, so that the platform has not been designed in the inter-track space. Therefore, there are proposed the following axial track spacings, assuming passenger routes leading to platforms at one level (no tunnels or footbridges) [7, 8, 10]:

– the track spacing when setting a signaling unit as well as lighting or electric poles are planned in the inter-track space $x_1 = 4.75$ m;
– the track spacing between which one-edged platforms are located $x_2 = 6.0$ m;
– the track spacing between which two-edged platforms are located $x_3 = 9.0$ m.

In addition, two variants of building the stop are presented, requiring widening the space between tracks No. 1 and No. 2 of the I-ordinate line, by virtue of the internal platforms designed. Like the previous Variants, tunnels and footbridges have not been planned.

Variant VII (Figure 8) includes one two-edged platform requiring the expansion of the track axis to the value of $x_3 = 9.0$ m by incorporating four reverse horizontal circular arcs of the radius $R = 1000$ m, separated by straight sections.

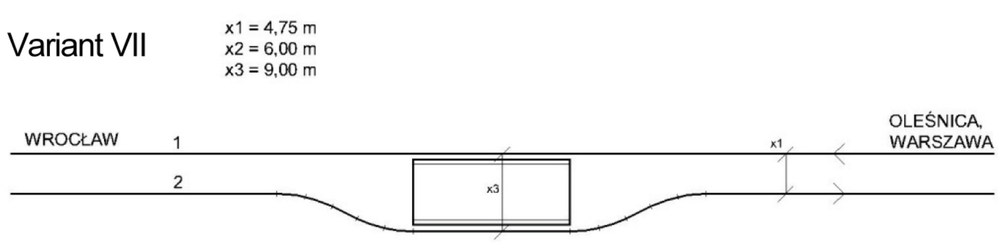

Fig. 8. Variant VII of the track layout of the passenger stop.
Source: own study.

In the case of Variant VIII (Figure 9) two one-edged platforms: external and internal ones are built in. It is required to extend the axis distance of tracks to the value of x_2 = 6.0 m. The expansion is carried out as described for Variant VII.

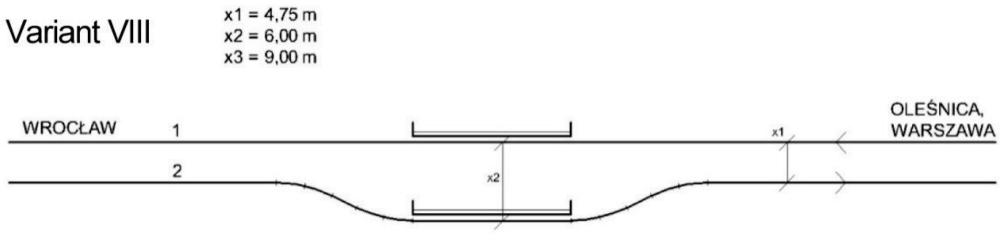

Fig. 9. Variant VIII of the track layout of the passenger stop.
Source: own study.

The length of the platforms must be adapted to the length of stopping trains. Since only local communication trains (e.g. Wroclaw-Oleśnica, Wroclaw-Kluczbork), i.e. rail buses, are expected to stop there, the length of the platforms should be suitable to the length of these train compositions.

As regards the solutions containing turnouts, it is proposed to incorporate ordinary turnouts with parameters [7, 10]:

- in the main fundamental tracks No. 1 and No. 2: turnouts of the 60E1 type, the taper of 1: 18.5; the curve radius of the diverging track R = 1200 m (these parameters provide passage in the diverging track at the speed of $v \leq 100$ km / h);
- in the additional tracks (for tracks No. 3 and No. 4 in Variants V, VI): turnouts of the 60E1 type, the taper of 1:12; the curve radius of the diverging track R = 500 m (these parameters provide passage in the diverging track at the speed of $v \leq 60$ km / h).

In all the newly built tracks of the stop it is recommended to use SB3 resilient fastenings of the rails to the sleepers.

It is advisable to use ZET-type platforms (ZIPWB, Kraków) with the wall containing the swiveling boundary plate [7]. This design ensures the height of the platforms over the rail head: h = 0.30 m; 0.55 m and 0.76 m.

3. THE CONCEPT OF IMPROVEMENT OF PUBLIC TRANSPORT FOR THE RESIDENTIAL ESTATE 'THE FOUR SEASONS'

3.1. THE LOCATION OF THE ESTATE AND THE EXISTING INFRASTRUCTURE

The Residential Estate 'Four Seasons', built after the year 2010, is located in the southern sector of the city of Wroclaw and belongs to the district Lamowice Stare (Figure 10) [13]. The border between the city of Wroclaw and the municipality of Siechnice surrounds it from the south and east. Its western side adjoins Buforowa Street, which is the Wroclaw - Strzelin road No. 395. Buforowa Street has one two-lane road. It is characterized by the considerably damaged bituminous surface (the speed limit of 40 km/h is set within the area of the Estate.) and there are no pavements. Bus transportation is the only means of public transport from and to the center of Wroclaw. The double track railway line No 276 (marked C59 / 2) connecting Wroclaw and Międzylesie, which is the section of the main line E59 to Prague, runs on the geographical axis of north-south at the distance of about 200 m from the eastern border of the Estate.

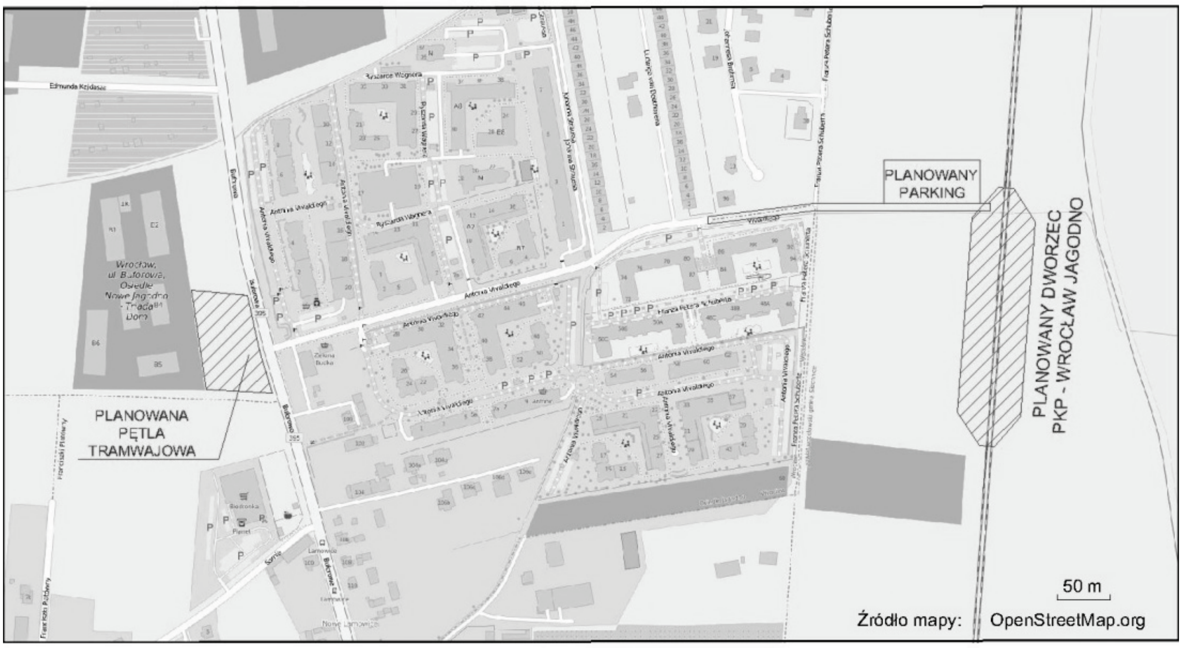

Fig. 10. The location of the Estate 'Four Seasons' and the flowchart of the proposed public transport stop on the PKP PLK S.A. line.
Source: own study based on [13].

3.2. THE PROPOSAL OF CONNECTING THE ESTATE WITH THE CENTER OF WROCLAW BY RAIL PUBLIC TRANSPORT

TRAIN PUBLIC TRANSPORT

The area around the railway line C59/2, in the vicinity of Schubert, Vivaldi and Graniczna Streets, is wasteland. Thus, the construction of the passenger stop on this railway line, identical to the stopping point in the village of Mirków, in terms of the geometrical layout and the surface was proposed in this zone of the Estate (Figure 10). At the eastern border of the city of Wroclaw, at the height of Vivaldi Street it is possible to locate a car park, which could function as the Park & Ride system. Schubert and Vivaldi Streets may constitute main traffic routes between the passenger rail stop, the Residential Estate and Buforowa Street, leading to the center of Wroclaw [13].

TRAM PUBLIC TRANSPORT

In the upcoming years the local government of Wroclaw is planning to modernize Buforowa Street and connect the districts of Jagodno and Lamowice Stare with the center of Wroclaw by tram transportation. The authors of this article point to the possibility of a tram line operating along Buforowa Street, outside the roadway (at the western border of the lane of the road), in view of the existing undeveloped land. The tramline could be carried out from the Plus tram loop, located in Świeradowska Street, parallel along Buforowa Street as a single track or a double track ended with a loop in the area of Vivaldi and Sarnia Streets. The proposal of the loop on a single-track tramline is shown in Figure 11. As for a double-track line, the tram loop is illustrated in Figure 12.

The alternative ending of the tram route can be made:

- in the case of a single-track line: using a single 'blind' track or a unit of two 'blind' tracks, one of which would be a stabling one (Figure 13),
- for a double-track line: in accordance with solutions given in Figure 14.

Schemes of variants of the stop track layout are presented by proposing the use of one-edged or two-edged platforms. The access of passengers to platforms is provided at the ground level, from the front or the side of the platform.

Particular solutions for a single-track line are shown in the six following variants (Fig. 13*a-f*):

- Variant I (Fig. 13*a*): the 'blind' single track No. 1,
- Variant II (Fig. 13*b*): two 'blind' tracks, one of which acts as a stabling or siding one, platforms designed before the turnout,
- Variant III (Fig. 13*c*): the system of three tracks - the main fundamental No. 1, the main additional track No. 2 and the 'blind' track No. 1a - enables the lane and direction

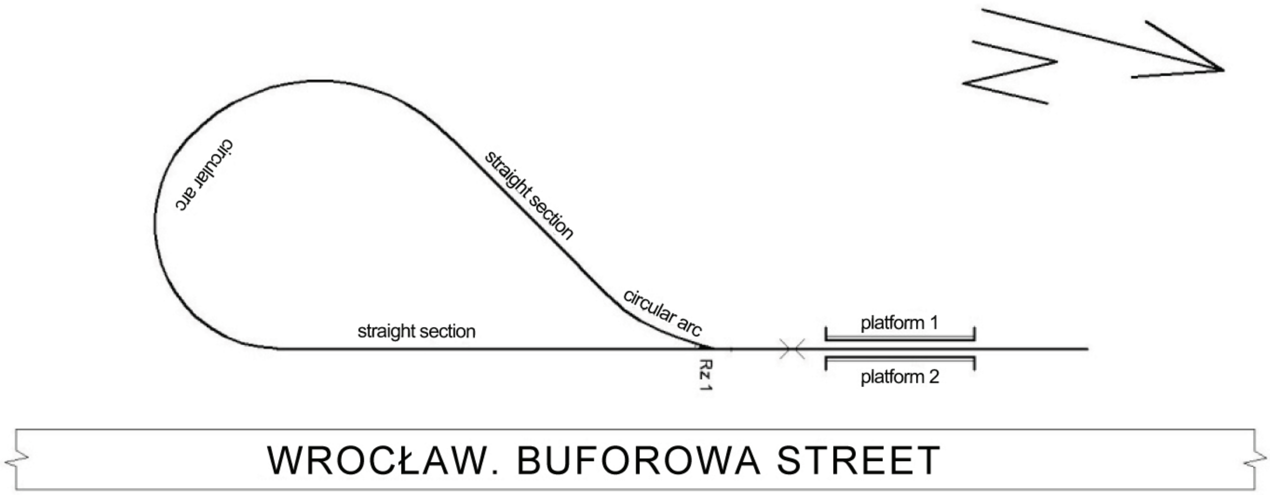

Fig. 11. The site plan (scheme) of the proposed tram loop for a single-track line.
Source: own study.

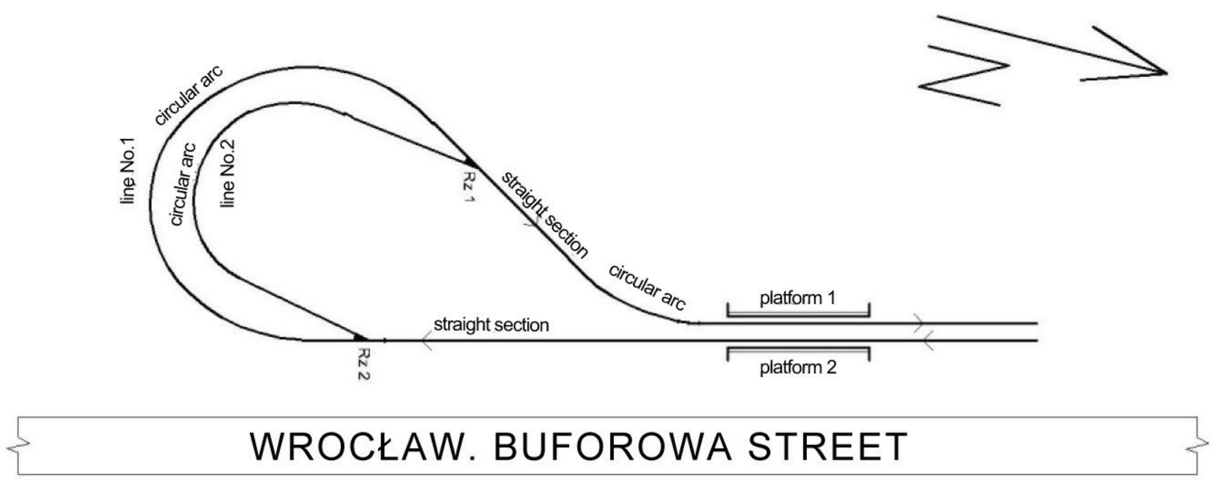

Fig. 12. The site plan (scheme) of the proposed tram loop for a double-track line.
Source: own study.

change; two external one-edged platforms with a shelter provided, operating the lanes No. 1 and No. 2,

- Variant IV (Fig. 13*d*): the system of three tracks as in the case of Variant III; the two-edge platform with a shelter between tracks No.1 and No. 2,
- Variant V (Fig. 13*e*): the system of two 'blind' tracks; the main fundamental track No. 1, the main additional track No. 3, two external one-edged platforms with a shelter,
- Variant VI (Fig. 13*f*): the track system as in the case of Variant V; the two-edged platform with a shelter is situated between tracks No. 1 and No. 3.

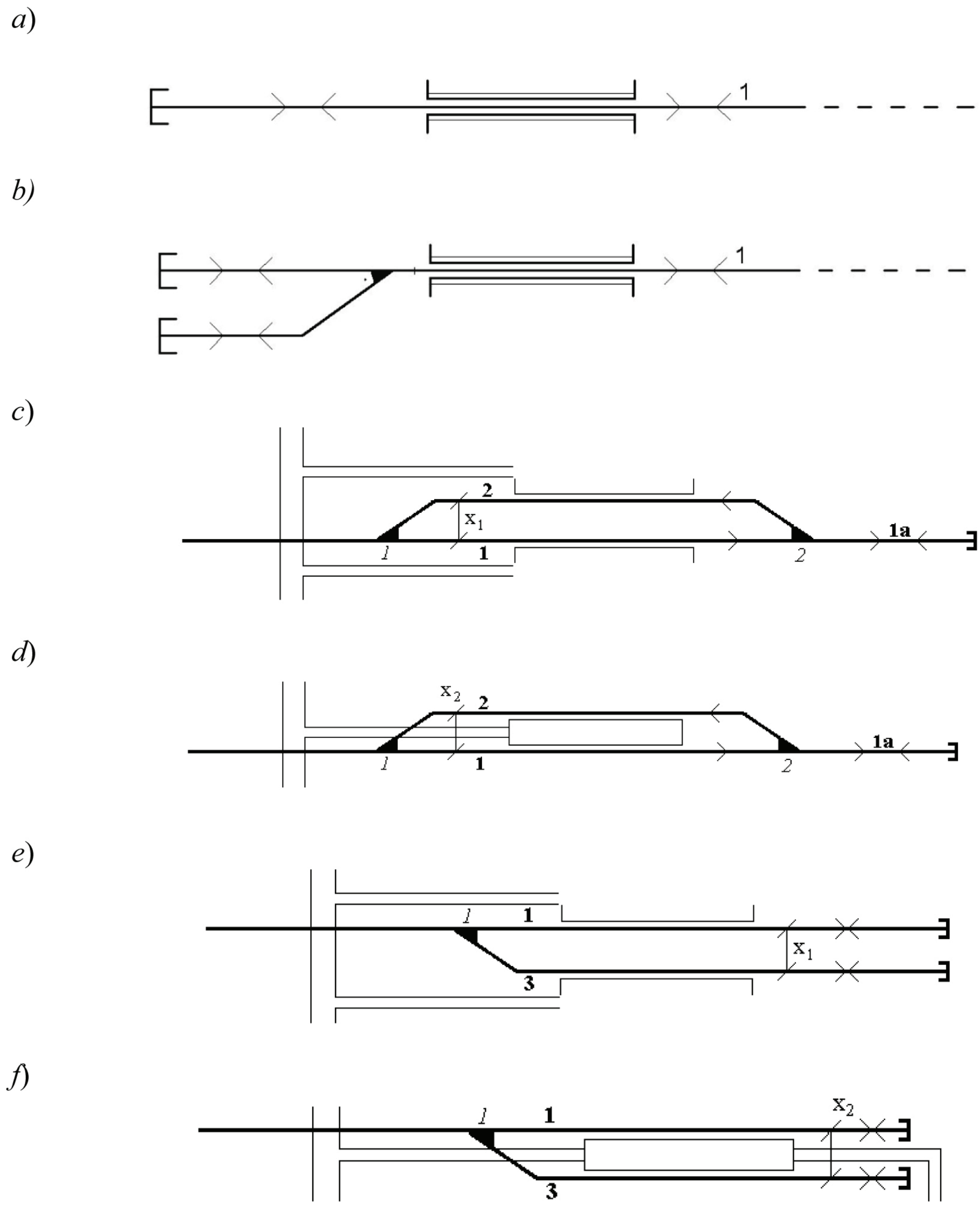

Fig. 13. The site plan (scheme) of the designed ending of the single-track tramline – Variants I, II, III, IV, V, VI of the solution.
Source: own study.

The proposed two variants of the ending of the double-track line are equipped with two one-edged platforms with a shelter and contain the following elements of the geometrical layout (Figure 14):

- Variant I: requiring the incorporation of four turnouts in order to enable a tram to change tracks; two 'blind' tracks may serve as maneuvering and stabling ones.
- Variant II: requiring the incorporation of three turnouts and a horizontal circular arc in order to enable a tram to change tracks; one 'blind' track may serve as maneuvering and stabling one.

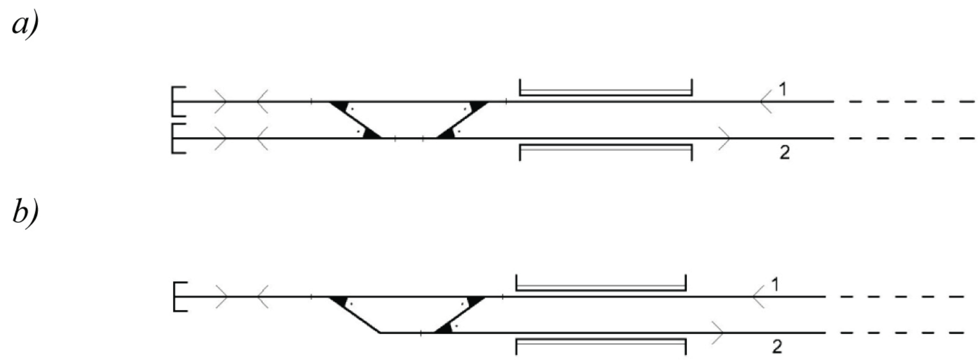

Fig. 14. The site plan (scheme) of the designed ending of the double-track tramline: *a* - Variants I and *b* - Variant II of the solution.
Source: own study.

Due to the fact that the tramline would run on a delimited track bed, the surface construction is proposed in two variants:

1) composed of layers (from the top): tram rails of the 180S type, typically tramway sleepers, the ballast (crushed stone of 0/63 mm) of the layer thickness h_t = 0.25 m; the protective layer made of fine aggregate (strengthening and serving as a filter); the geosynthetic mat as separation layer; the existent subgrade
2) typical for the contactless railway track, i.e. consisting of layers (from the top): railway rails of the type 60E1, pre-stressed concrete sleepers PS83 or PS94, the SB3 resilient fastening of rails to the sleepers, the ballast (crushed stone of 0/63 mm) of the layer thickness h_t = 0.30 m; other layers as mentioned before. In the track layout of the so-called terminal station it is recommended to built in turnouts with the parameters: 60E1 type, the taper of 1:12; the curve radius of the diverging track R = 500 m. It is permissible to use turnouts of the type 49E1, with the taper of 1: 9, the radius of the diverging track R = 300 m or 190 m.

It is recommended to install expansion joints in the track according to the provisions of the Regulation [8], reducing the transmission of horizontal forces (generated by temperature changes) from the track to the subgrade. These joints would be applied at distances of about 400 meters in the track of the tramline.

The construction of the subgrade under the track with dehydration should be performed in accordance with applicable technical guidelines [5].

4. CONCLUSIONS

Given that the presented solutions are of concept nature, a number of significant problems are not mentioned in the article. The most important ones include:

- the project of the track dehydration of train stops and of the tramway [3, 7]
- determination of the geometrical parameters of the tramline (the minimum width of a delimited double-track tramline on the route, the circular arc radius in the track plan, the values of track longitudinal gradients and radii of potential vertical arcs) [3, 4, 7, 8, 10].

In addition to the reconstruction of the track layout, the performance of the following tasks is expected in the area of construction of passenger stops regarding both of the abovementioned railway lines:

- replacing the existing surface (the installation of the SB3 resilient fastenings of rails to the sleepers) [4, 7, 10, 12];
- mounting the pre-stressed concrete sleepers, the replacement of the existing ballast bed [11];
- strengthening the track substructure (in the case of insufficient load-capacity; the required module at the level of the track is $E \geq 110$ MPa on railway lines No. 143 and C59 / 2 being considered in the article) [5, 11],
- the general pavement overhaul at the intersection at the level of the track rails with Kiełczowska Street, in the zone of the projected Mirków passenger stop [2].

Presented in the article the problems are only the basic stage of a wide topic. For this reason, we are given only the same technical solution is not considering a variant that would be dedicated to the expected torrent of passengers. The authors predict a continuation of the theme, ie technical and economic analysis of variants based on the measurement of the size of the stream of passengers at different times of the year, taking into account rush hour. The authors are well aware that it has taken on the character and development.

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