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Analysis of realization of public transport between Pyskowice town and Katowice city in the Silesian agglomeration using buses of the KZK GOP company

The organization of public transport is an important element of a sustainable transport policy in the region. This is particularly relevant and important to the organization of transport in areas with a high degree of urbanization, for example Silesian Agglomeration. The article presents an analysis of connections organized by KZK GOP on the route allowing access from one of the smaller towns (Pyskowice) located in the Silesian Agglomeration to Katowice city.

Introduction

The Silesian Province is one of the most densely populated areas of Poland, and has a very dense transport network, particularly in the field of land transport (both road and rail). This is due to a number of factors, mainly the historical and social. Already in the late XIX and early XX century, the area of the Silesian province (especially the area of Upper Silesia) was a heavily industrialized area - mainly because of the large numbers of areas which were and still are rich in deposits of coal. As a result of these factors developed in this area numerous mining business, which to the smooth functioning, required to provide adequate resources, both human resources and infrastructure. Human resources is primarily personnel (both managers as well as specialized and non-specialized workers), while the infrastructure is mainly railway infrastructure (transport of carbon in those days was carried out mainly by rail) and partly road.

After the Second World War the situation in the region also looked very similar. Still rich deposits of coal and other fossil ore contributed to the significant expansion of existing plants in the area of mining and manufacturing (mainly in the processing of steel). These factors contributed to a significant increase in the attractiveness of the region in terms of social and household. Human resources needs have caused a significant influx of people into the area and the expansion of infrastructure including road infrastructure, housing and social services (schools, universities, hospitals, etc.).

A large number of plants and their deployment on a relatively large area caused that in the central part of the Silesian province expanded to not one, but several urban centers in one of the establishments located there, housing estates and social infrastructure. As a result of the lack of a central hub (of course province has a city which acts as a central and it is a city of Katowice, but the function of the city more results from historical circumstances and not, eg. dominance of Katowice over other cities in terms of expansion, population, etc.), it was necessary to create efficient transport system and expansion of infrastructure (both road and rail) to the needs of both industrial and allow the movement of the inhabitants of one city to another.

Very often employees live in a town other than the place of work, which generates significant traffic flows, now mainly individual cars which greatly contributes to the congestion of transport [1]

in the region and has a negative impact, among others, on the environment and are inconsistent with the objectives of the European Union in the organization and implementation of sustainable transport which is written for example in [23]. A large part of the inhabitants of the region and the central area, for various reasons (eg due to less noise and pollution) inhabits not only major urban areas, but also smaller towns (as even Pyskowice), and for these people it is also necessary to enable the efficient movement and from the central areas, preferably using public transport.

The implementation of efficient and effective public transport is not an easy task. This transport must consist of a number of important factors, for example it must be.:

- ◆ available;
- ◆ comfortable;
- ◆ rapid (time to reach the destination is comparable to or faster than travel time by individual transport);
- ◆ economically viable for the traveler.

The fulfillment of all these factors is very difficult [2, 3, 4, 5, 6, 7, 8, 9, 10, 22] and in addition to providing adequate fleet in terms of quality (modern, comfortable and reliable rolling stock) and quantitative (number of means of transport, the number of courses conducted during the day, etc.) Requires an appropriate manner. One of the key elements of the organization is to prepare the optimal schedules. Currently schedules can be planned, analyzed and optimized in many ways, either by using an analytical approach, simplified (the use of simplified methods) [10] as well as can be done using a simulation support [2, 3, 6]. Importantly, even after the development of timetables needed their ongoing monitoring and analysis in terms of meeting the expectations of travelers.

Public transport collective in the Upper Silesian agglomeration (in its central part) is carried out by several operators in different modes of transport. Predominant group are carriers providing services of buses, but apart from them, they are also provided services with using rail transport (railway and tram) and trolleybuses.

1. Public bus transport in Silesian province

Bus transport in the Silesian province is implemented by several entities with different legal status (company, association of municipalities, etc.). The largest of them are:

- ◆ KZK GOP,
- ◆ MZK Tychy,
- ◆ PKM Jaworzno,
- ◆ MZKP in Tarnowskie Góry.

The above-mentioned entities are not individual companies, but each of them is a collection of entities performing under one "umbrella" transport services in a separate area.

The entity implementing the majority of transport within the Katowice conurbation is a KZK GOP company, which according to the data provided by them supports an area of 1.7 thousand km², which is inhabited by almost 2 million people [25].



Fig. 1. Localization of Pyskowice town on KZK GOP activity area [25]

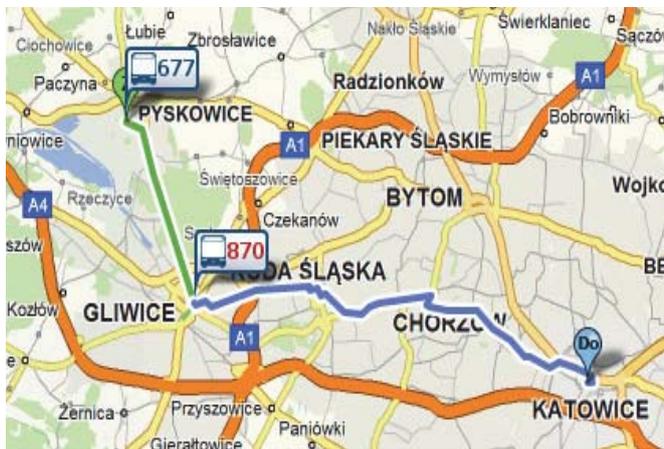


Fig. 2. The route from Pyskowice to Katowice using bus public transport offered by KZK GOP [28]

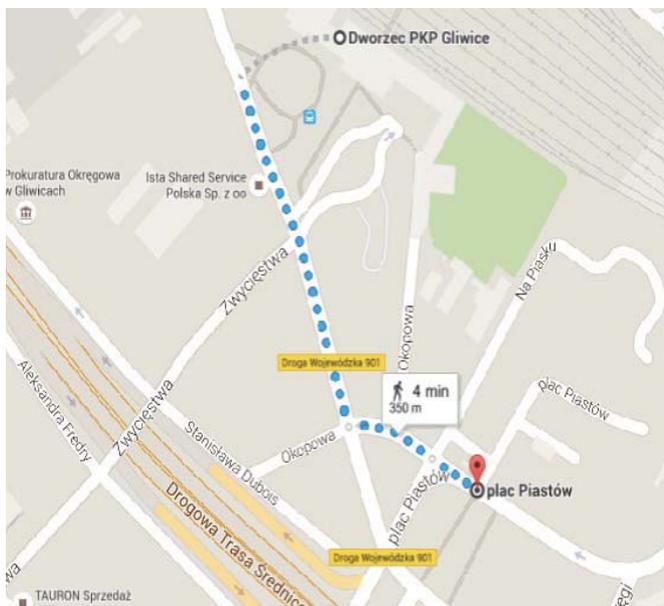


Fig. 3. Route transition between the Gliwice Dworzec PKP bus stop and Gliwice Plac Piastów bus stop. [27]

A large number of entities performing transport in the agglomeration causes the creation of a single, coherent communication system is a very difficult task for both the organizational as well as technical and very often in order to reach from one area of the agglomeration to another requires the use of the services provided by different carriers, or make interchange between 2 or 3 means of transport organized by a single carrier.

2. Pyskowice town

Pyskowice is one of the oldest towns of Upper Silesia [26]. The town is located in south-western Poland, in the western part of Silesia, and Upper Silesian Industrial Region (GOP), in the northern part of the district of Gliwice Katowice Upland, on the Drama river. Historically it lies in Upper Silesia and is directly adjacent to the city of Gliwice and municipalities:

- ◆ Rudziniec, Toszek, Wielowieś (district of Gliwice);
- ◆ Zbroslawice (district tarnogórski). [29]

According to the data of the Pyskowice municipal office area of the municipality is 3 114 ha, of which 1 693 hectares are covered by buildings of a city.

The population as of 31 December of 2015 amounts to 17205 people, including:

- ◆ from 0 to 17 - 2722
- ◆ 18 to 64 - 11771
- ◆ over 64 - 2712 [29].

So as we can see from the above data, the city is inhabited mainly by young people and people in “productive” age. Also for this reason it is essential that the town had a convenient connection to collective communication with the capital of the region and the province.

The town is located in the northern part of the KZK GOP activity, as shown in Figure 1 (red indicated the Pyskowice town, a yellow city of Katowice.)

The aim of the trip from Pyskowice to Katowice it is necessary to use the minimum of 2 buses, between which you have to change in the center of Gliwice. An example of a route of travel from Pyskowice to Katowice is shown in Figure 2.

Travel from Pyskowice to Katowice is possible with the use of several different connections, but the carrier on their website us-



Fig. 4. An example of the so-called KZK GOP “Night line” bus [24]

Tab. 1. Analysis of the waiting time between KZK GOP 677 & KZK GOP 870

Arrival of KZK GOP 677 on bus stop Gliwice Dworzec PKP	Departure of KZK GOP 870 from bus stop Gliwice Plac Piastów	Waiting time [min]
00:02		
04:35	04:39	00:04
	05:04	00:29
	05:29	00:54
05:37	05:44	00:07
	05:59	00:22
06:12	06:24	00:12
06:42	06:44	00:02
	06:59	00:17
07:11	07:29	00:18
07:36	07:54	00:18
07:46		00:33
08:11	08:19	00:08
08:41	08:54	00:13
09:11	09:34	00:23
09:40		00:34
10:11	10:14	00:03
10:41	10:44	00:03
	11:14	00:03
	11:44	00:33
12:11	12:14	00:03
	12:44	00:33
	13:14	00:03
	13:34	00:23
	13:49	00:38
	14:09	00:58
14:11	14:29	00:18
14:41	14:54	00:13
	15:09	00:28
15:11	15:29	00:18
15:41	15:54	00:13
16:11	16:14	00:03
16:30	16:49	00:19
16:41		00:08
17:11	17:34	00:23
17:40		00:54
18:11	18:34	00:23
18:40		
19:08		
20:08		
21:08		
22:08		
23:35		

Tab. 2. Analysis of the waiting time between KZK GOP 677 & KZK GOP 840

Arrival of KZK GOP 677 on bus stop Gliwice Dworzec PKP	Departure of KZK GOP 840 from bus stop Gliwice Plac Piastów	Waiting time [min]
00:02	04:15	04:13
04:35	04:40	00:05
	05:11	00:36
	05:31	00:56
05:37	05:51	00:14
06:12	06:14	00:02
	06:29	00:17
06:42	07:04	00:22
07:11	07:44	00:33
07:36		00:53
07:46	08:29	00:43
08:11		00:18
08:41	09:15	00:34
09:11		00:04
09:40	10:00	00:20
10:11		00:34
10:41	10:45	00:04
	11:30	00:19
	12:00	00:49
12:11	12:30	00:19
	12:59	00:48
13:11	13:29	00:18
	13:59	00:48
14:11	14:29	00:18
14:41	14:59	00:18
15:11	15:29	00:18
15:41	15:59	00:18
16:11	16:29	00:18
16:30		00:44
16:41	17:14	00:33
17:11		00:03
17:40		00:31
18:11	18:11	00:00
18:40		00:33
19:08	19:13	00:05
20:08	20:13	00:05
21:08	21:13	00:05
	22:12	00:04
22:08	22:53	00:45
23:35		

Tab. 3. Analysis of the waiting time between KZK GOP 677 & KZK GOP 6

Arrival of KZK GOP 677 on bus stop Gliwice Dworzec PKP	Departure of KZK GOP 6 from bus stop Gliwice Dworzec PKP	Waiting time [min]
00:02	04:28	04:26
04:35	04:50	00:15
	05:16	00:41
05:37	05:46	00:09
06:12	06:16	00:04
06:42	06:46	00:04
07:11	07:16	00:05
07:36		00:10
07:46	07:46	00:00
08:11	08:16	00:05
08:41	08:46	00:05
09:11		00:35
09:40	09:46	00:06
10:11		00:35
10:41	10:46	00:05
	11:16	00:05
	11:46	00:35
12:11	12:16	00:05
	12:46	00:35
13:11	13:16	00:05
	13:46	00:35
14:11	14:16	00:05
14:41	14:46	00:05
15:11	15:16	00:05
15:41	15:46	00:05
16:11	16:26	00:15
16:30		01:02
16:41	17:32	00:51
17:11		00:21
17:40		00:59
18:11	18:39	00:28
18:40		00:59
19:08	19:39	00:31
20:08	20:39	00:31
21:08		
22:08		
23:35		

ing the search engine suggests to take advantage of the following preferred connections:

- ◆ Bus number 677 to Gliwice, then change to a bus 870 in the direction of Katowice;
- ◆ Bus number 677 to Gliwice, then change to a bus line 840 in the direction of Katowice;
- ◆ Bus number 677 to Gliwice, then change to a bus line 6 in the direction of Katowice.

A very important element hampering trip is for two relations (677 - 870 and 677 - 840) the need - in addition to the changes in the means of transport - the transition between the Gliwice Dworzec PKP bus stop (bus stop, where buses 677 stop) and Gliwice Plac Piastów bus stop (bus stop of a bus going in the direction of Katowice.) Both stops are located in the center of Gliwice, and the transition between them takes about 4 minutes. An example of a route of passage between bus stops is shown in Figure 3.

For relation bus 677 and bus 6 is not required to transition between bus stops.

Research methodology

As part of the study were analyzed the plates of bus routes, bus trips and web applications provided by KZK GOP, whose task is the ability to search a connections. Studies presented below are an extension of the research described in [11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21] of the connections made to other popular in the region of connections relationship. The following article describes the number of connections and the transfer time for the line No. 677 from Pyskowice aim of switching to KZK GOP lines that allow access from Gliwice to Katowice.

The studies were obtained times of arrivals line KZK GOP 677 to the bus stop Gliwice Dworzec PKP and departure times of buses KZK GOP lines 870 and 840 with a stop at Gliwice Plac Piastów bus stop and departure times of buses line 6 from Gliwice Dworzec PKP bus stop.

The following tables 1 to 3 presents a comparison of the arrival time of the bus line KZK GOP 677 with departure times of buses KZK GOP lines 870, 840 and 6. In Tables 1 to 3, blue color indicated waiting time between connections amounting to more than 30 minutes, while red indicated time expectation equal to 5 minutes or less - it is a short waiting time, for which there is a high risk of being late for buses going in Katowice direction because of the need to move from a Gliwice Dworzec PKP bus stop to Gliwice Plac Piastów bus stop or due to the delay in the timetable of the first bus (for interchange on the line 6).

In accordance with the data in Table 1, for 33 arrivals KZK GOP bus line No. 677 change is possible for 36 connections with buses KZK GOP 870. The average waiting time - without considering the connections that require long waiting - is 13 minutes, however, in the extreme case this time is 58 minutes.

In accordance with the data in Table 2, for 31 bus arrivals line KZK GOP No. 677 change is possible for 39 connections with buses KZK GOP 840. The average waiting time - without considering

Tab. 4. The average waiting time and the percentage of links for connection from KZK GOP 677 on KZK GOP bus lines going to Katowice

	Bus line			
	KZK GOP			
	677	6	840	870
Number of connections:	31	21	23	28
Percentage of connections which allows the bus change [%]:		63.64	69.70	84.85
The average waiting time [min]:		00:07	00:11	00:11

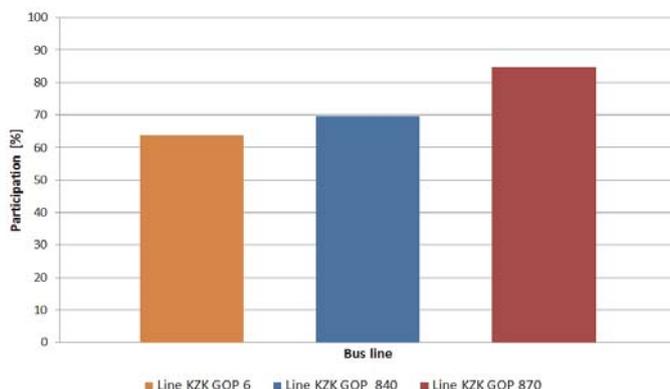


Fig. 5. The percentage of connections from KZK GOP 677 on the other lines which drive to the center of Katowice
Source: Own calculations based on Table 4.

the connections that require long waiting - is 11 minutes, however, in the extreme case this time is 56 minutes.

In accordance with the data in Table 3, for 33 arrivals KZK GOP bus line No. 677 change is possible for 34 connections with buses KZK GOP 6. The average waiting time - without considering the connections that require long waiting - is only seven minutes, but in the extreme case this time be up to 1 hour and 2 minutes.

The above data on the possible number of transfers apply to all possible connections, but how it is presented in Tables 1 to 3, buses going from Gliwice to Katowice run more frequently than buses from Pyskowice to Gliwice, which means, that passengers do not benefit a large number of connections, because they choose earlier connection to continue their journey.

Also very important is difference during a trip undertaken using public transport and individual transport (car). Travel by public transport takes about 1 hour 45 minutes to almost 2 hours, by individual transport the same route is carried in a period of about 1 hour 10 minutes.

The information contained in Tables 1 to 3 relating to waiting times and the number of connections, together with their percentage share in relation to the timetable of the bus line KZK GOP 677 is shown in Table 4, these data do not include connections that require long waiting times, which probably would not be used by the passengers to continue a journey on this relationship.

According to the information given in Table 4 connections are possible for almost

every bus line KZK GOP 677. Percentage of possible connections in each case is above 60%, which according to the author is not such a bad result (note that the data in Table 4 do not include connections that require long waiting). Unfortunately analyzing Tables 1 to 3 can be seen that the bus line KZK GOP 870 and 6 are missing connections in the evening. The last bus line 870 departs from the Gliwice Plac Piastów at 18:11, while the bus line 6 departs from the Gliwice Dworzec PKP at 20:08. Later connection is only possible with the use of line 840. Importantly line 840 also does not provide a connection for the last bus line KZK GOP 635, which arrives in Gliwice at 23.35.

None of the analyzed line is not also provides convenient connections for the first bus that arrives from Pyskowice to Gliwice at 0:02, but the problem has been solved through the night line 840N course, which from Gliwice Plac Piastów departs in Katowice direction at 00:14. An example of the so-called "Night line" bus is shown in Figure 4.

Figure 5 shows the percentage of connections from KZK GOP 677 on the other lines, while Figure 6 shows the waiting times to change buses between the line KZK GOP 677, and lines KZK GOP which drive to the center of Katowice.

Summary

Implementation of connections with the city Pyskowice and Katowice using the line KZK GOP 677 and proposed by the carrier lines 6, 840 and 870 is realized in a pretty good manner. Noteworthy is the fact that there is a quite large number of possible connections and the average waiting time is not too long. Importantly, there are practically no connections for which, buses from Gliwice depart in Katowice direction before the arrival of the bus from Pyskowice.

Unfortunately, the proposed connections have also some elements which require further elaboration. A large number of connections is with waiting time of less than 5 minutes, which in conjunction with the need to arrive at the second stop located at a distance of about 350 meters and combined with the risk of delay the bus from Pyskowice. It means that there is a very high probability of being late for the bus which goes in Katowice direction. Another important element is the fact that a large number of buses going in Katowice direction is not an immediately preceding

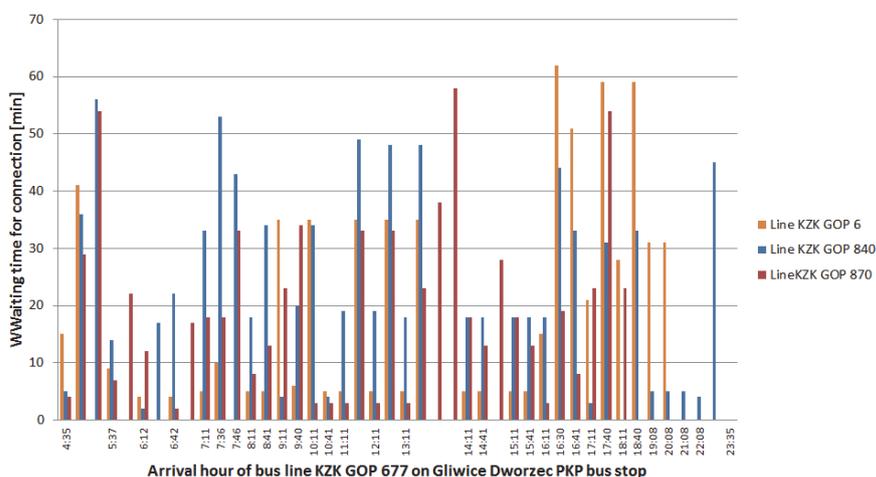


Fig. 1. Number of connections and waiting time for connection from the line KZK GOP 677 on the buses which goes to Katowice at the Gliwice Plac Piastów bus stop - without the arrival of bus line KZK GOP 677 at 0:02
Source: Own calculations based on Table 1-3.

the connection of Pyskowice, which may also adversely affect the selection of the connection.

The main problem observed by the author is a time traveler by public bus transport which in the extreme case is almost two times longer than in the case of individual transport.

Therefore, according to the author, KZK GOP should consider a slight modification of the proposed timetables and what is important, increase the traveling speed of buses (mainly on the route Gliwice - Katowice), so that the travel time was comparable to the driving using individual transport.

Those actions should contribute to the gradual ever greater interest in the use of public transport instead of individual transport.

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Analiza realizacji transportu zbiorowego pomiędzy miastem Pyskowice a miastem Katowice z wykorzystaniem komunikacji autobusowej organizowanej przez KZK GOP

Organizacja transportu zbiorowego stanowi istotny element polityki zrównoważonego transportu danego regionu. Jest to szczególnie istotne i ważne podczas organizacji transportu na obszarach o wysokim stopniu urbanizacji, jak np. Aglomeracja Górnośląska. W artykule przedstawiono analizę połączeń organizowanych przez KZK GOP na trasie umożliwiające dojazd z jednej z mniejszych miejscowości (Pyskowice) zlokalizowanych na terenie Aglomeracji Górnośląskiej w kierunku Katowic.

Słowa kluczowe: Aglomeracja Górnośląska, zrównoważony transport, transport publiczny, transport autobusowy, KZK GOP, połączenia autobusowe Pyskowice–Katowice