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ABSTRACT

The article is devoted to the issue of accessibility of public transportation in the area of the Katowice conurbation. The scope of the research was local mass transit, that is tram, trolleybus and bus transportation. The research area, was established on the basis of the shape created by the transport network, and included 48 communities located in the central part of the Silesian voivodeship. In its model depiction, public transportation accessibility was treated as one of three interconnecting aspects, along with the infrastructural development and the offer level. In research on spatial accessibility, the method of model equidistances that replace the isochrones of distance to a stop was applied. The best accessibility to this service was observed in Siemianowice Śląskie, while the worst was in the community of Wielowieś. The research results have revealed significant discrepancies between public transportation accessibility itself, and the level offered. Research on the time of transit to the centre was performed with the use of an indicator constructed with the help of the point and rank method and this showed that the best accessibility to the centre was observed in Chorzów. The research on the time of transit between community centres was performed for all the communities with the use of direct connections and transfers. The shortest average time of transit was characteristic for Katowice, whereas the longest was in the community of Pilchowice. The research on transportation connections of public transportation completed the picture of accessibility. A measure of these connections was established as an average total number of inter-community connections for all days of the week. Katowice was characteristic of the best spatially developed network of connections whereas the most developed connections were observed between Katowice and Chorzów. The comparison of public transportation accessibility in the system of communities was performed with the quality classification method, on the basis of four previously characterized meters. According to the synthetic indicator, the best accessibility was in Katowice and the worst in the rural community of Bobrowniki. The results of the conducted research have confirmed the presence of dependence between accessibility and population density – the higher the population, the better the accessibility. They also indicate that in the research on accessibility, the role of time is not to be neglected – the research area being an example, where despite the transportation network covering a territory of almost 3 thousand km^2, the real possibilities for moving are much lower due to the time of transit.

KEY WORDS: mass transit, urbanized areas, accessibility, Silesian voivodeship

1. Introduction

Transportation accessibility constitutes one of the research fields in geography that perfectly fits into its classical paradigm, that is the differentiation of phenomena in time and space. In foreign literature, this issue has been discussed not only in articles, but also in monographic studies, e.g. GEURS (2006), GEURS ET AL. (2012), TYLER (2002), SURHONE ET AL. (2011). In Poland, research on transportation accessibility has also been done for many years, however, most sources on the topic are articles. In these articles, several definitions of transport accessibility may be found, which prevents one from providing one, universal definition (RATAJCZAK, 1999), WARAKOMSKA (1992), TAYLOR (1997, 1999), GUZIK (2003) and KOMORNICKI ET AL. (2010) have attempted to organize the terminology in this area. In its most straightforward depiction, transportation accessibility is the possibility of using the service of a particular type of transport and reaching a particular destination with its help. Accessibility in this meaning, has been researched in the area of the Katowice conurbation for public transportation (that is mass local transport organized by particular communities), including:

trams, trolleybuses and buses. The research was performed as of 1 January 2008. Changes that have taken place since do not have a significant influence on the achieved research results. The research area, established on the basis of the shape of the transportation network (Fig. 1), consisted of 48 communities (i.e. 28 urban, 2 urban- rural and 17 rural) covering an area of 2913 km^2 and inhabited by 2 million 505 thousand people (2008).

In the model depiction, a reference was made to the system depiction of transport in geography (POTRYKOWSKI & TAYLOR, 1982) by designating three aspects of public transportation research: the infrastructure, the level of the offer and the accessibility. The article discusses the last of the mentioned aspects, which is especially crucial due to being a derivative of infrastructural development and the level of public transportation offer and it decides on the competitive position of mass transit versus individual transport as well as on the choice of the means of transport made by passengers.

Maps constitute classic tools applied in the research on accessibility in transport, but there are also their extensions in the form of GIS systems and timetables. This research used a custom-created data base with timetables of all 447 public transportation routes (34 tram lines, 5 trolleybus lines, 408 bus lines) in the Katowice conurbation, and also a detailed map of the public transportation network made on the basis of the data base, at the scale of 1:50 000, which includes the routes of all transportation lines as well as the location of all 3 thousand stops, verified by field research.

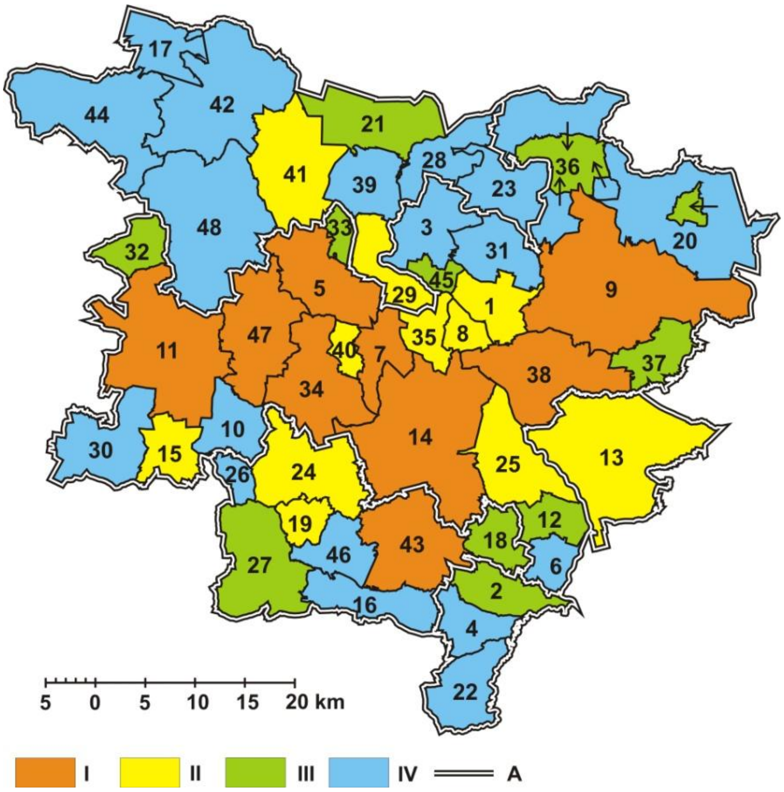

Fig. 1. Research area (own study)

I – cities; II – medium towns; III – small towns or urban part of urban-rural communities; IV – rural communities or rural part of urban-rural communities; A – division of the organizers of the public transport; 1 - Będzin, 2 - Bieruń, 3 - Bobrowniki, 4 - Bojszowy, 5 - Bytom, 6 - Chełm Śląski, 7 - Chorzów, 8 - Czeladź, 9 - Dąbrowa Górnicza, 10 - Gierałtowice, 11 - Gliwice, 12 - Imielin, 13 - Jaworzno, 14 - Katowice, 15 - Knurów, 16 - Kobiór, 17 - Krupski Młyn, 18 - Lędziny, 19 - Łaziska Górne, 20 - Łazy, 21 - Miasteczko Śląskie, 22 - Miedźna, 23 - Mierzęcice, 24 - Mikołów, 25 - Mysłowice, 26 - Ornontowice, 27 - Orzesze, 28 - Ożarowice, 29 - Piekary Śląskie, 30 - Pilchowice, 31 - Psary, 32 - Pyskowice, 33 - Radzionków, 34 - Ruda Śląska, 35 - Siemianowice Śląskie, 36 - Siewierz, 37 - Sławków, 38 - Sosnowiec, 39 - Świerklaniec, 40 - Świętochłowice, 41 - Tarnowskie Góry , 42 - Tworóg, 43 - Tychy, 44 - Wielowieś, 45 - Wojkowice, 46 - Wyry, 47 - Zabrze , 48 - Zbrosławice

2. Time and spatial accessibility of stops

The level of transportation accessibility is decided upon by a number of factors, including: the time lost in transit, the cost of transit, the time (period), the place and the method of providing a service, the safety of transit, the knowledge of public transportation, including the possible transit routes and the location of stops, as well as the individual preferences of users (Technical Guidance on Accessibility Planning 2004, p. 4). A key role in the aspect of accessibility, but also in all other transportation processes, is played by time – the time of getting to, or from, the stop by a potential passenger, as well as the time lost in transit. Therefore, the first factor that decides on public transportation accessibility is the number and the allocation of stops.

The range of the impact of a stop is defined as an area from which potential passengers have the possibility of walking with no major effort required (BEIM & GADZIŃSKI, 2009). The walking distance to the nearest stop is not regulated by any planning norms in Poland – it is only a proposed standard of service. In reference books, the proposals of the Institute of Urban and Spatial Management are most frequently found. Initially, it was recommended that the walking distance to the stop should not exceed 250 to 500 m, depending on circumstances (WIĘCKOWSKI, 1988); later on, it was specified to 300 m for the central area, from 400 to 500 m in multi-family housing developments and from 600 m to 800 m for one-family housing developments (e.g. ROZKWITALSKA, 1994). Similar values were proposed by ROŚCISZEWSKI (1996).

In the research on stop accessibility, frequently adopted measures are isochrones of the real time of walking to the stop. There are no unambiguous and generally recognized norms in this area. On the basis of surveys, WYSZOMIRSKI (1997) determined that the average time of getting to a stop should not exceed 7 minutes, whereas REJMONIAK (1985) adopted a slightly higher value of 10 minutes as a criterion of efficiency of the transportation system. The same value was also adopted as a maximally accepted time distance and divided into zones of good (up to 5 minutes) and acceptable (5 to 10 minutes) walking time to a stop. The perception of walking time to the stop depends on the distance and conditions for walking (RUDNICKI, 1999). People physically fit see the distance differently than older people with mobility dysfunctions, who move considerably slower.

The isochrones of 5 and 10 minutes may be converted into model equidistances – applying the principle of a pedestrian moving at a speed of 4.8 km/h and for every theoretical isochrone, there is a certain time loss connected with impediments that may happen on the road and extend the transit and, in effect, they decrease the spatial range of the stop's impact. The main barriers that extend walking time to the stops are: unfavourable landscape, hydrographic barriers, crossroads with traffic lights, under- and overpasses, lack of pedestrian crossings, lack of pavements, fenced-off blocks of estates, etc. Therefore, an average and uniform level of impediments for all stops that were adopted amounted to 20% of the walking distance. After the calculation of isochrones, model equidistances were valued at 330 m and 660 m.

Calculations made on the basis of the transportation network map have been used to compare the accessibility of stops in specific communities of the conurbation. This accessibility was established with the aid of model equidistances corresponding with two zones of walking distance – the good and the acceptable walking distances to a stop. It was assumed that a stop is a complex of stands of various tractions, altogether providing for the same area and most frequently having a common name. The place, from which the impact of a stop is designated, is not its geometric centre, but it includes a varied number of departures from stands functioning within a stop. The research took into account only those stops that have over 20 departures a day. In this way, the stops with rare occurrences of public transportation could be eliminated, due to the offer lacking its functionality.

The calculations revealed that with the assumed threshold of a minimal number of connections, 23.5% of the conurbation is within the 5-minute walking distance zone to the nearest stop, in the zone of 5 to 10 minutes – 26.1% of the area and in the zone of over 10 minutes, reckoned as an unacceptable distance – 50.4% of the conurbation. Cities and medium towns were characterized by better accessibility of public transportation – in the acceptable zone there was 68.2% and 62.6% of their area, respectively. In small towns and rural communities, it was only 32.0% and 35.2% of the area. The best spatial accessibility to public transportation among cities was in Chorzów (84.3%), among medium towns – in Siemianowice Śląskie (91.4%), among small towns – in Wojkowice (86.0%) and in rural communities – in Psary (83.3%). Values for particular communities are presented in Table 1.

Good spatial accessibility to public transportation is characteristic for specific types of centres: with small area, high population density, spatially compact development, and with a developed transportation network. The presence of large areas within administrative borders, where mass transit service is not required (e.g. forests, water reservoirs, farmland) causes that even with a well-developed network, in the remaining part of these units the accessibility to public transportation calculated in relation to the total area will be low. It is clearly visible in Dąbrowa Górnicza, with its substantial differentiation and contrasts in development.

Due to a significant diversification of the level of the public transportation offer, when analyzing spatial accessibility, additional conditions were introduced in the zone of a 5-minute walking distance to stops, in the form of total number of departures from a stop within 24 hours on business days – over 200 and over 100 departures. The threshold of 200 departures statistically corresponds with a line running every 10 minutes, which means a possibility to start a transit without having to adjust to the timetable. Calculations have revealed considerable discrepancies between the accessibility to public transportation itself and accessibility to public transportation, taking into account the level of its offer.

Table 1. Spatial accessibility of public transportation stops (own study)

City, town or community	Percentage of community area within walking distance to stops zones in %			City, town or community	Percentage of community area within walking distance to stops zones in %		
	Under 5 minutes	From 5 to 10 minutes	Over 10 minutes		Under 5 minutes	From 5 to 10 minutes	Over 10 minutes
Cities over 100 thousand inhabitants				Medium towns – from 20 to 100 thousand inhabitants			
Bytom	40.0	35.4	24.6	Będzin	55.0	35.7	9.3
Chorzów	52.0	32.3	15.7	Czeladź	47.6	40.4	12.0
Dąbrowa Górn.	26.9	29.3	43.8	Jaworzno	24.6	27.1	48.3
Gliwice	33.5	31.5	35.0	Łaziska Górne	16.7	22.4	60.9
Katowice	37.9	27.2	34.9	Knurów	41.2	41.6	17.4
Ruda Śląska	40.1	37.4	22.5	Mikołów	21.7	31.8	46.5
Sosnowiec	47.3	33.9	18.8	Mysłowice	36.0	37.4	26.6
Tychy	39.6	25.5	34.9	Piekary Śląskie	33.3	37.9	28.8
Zabrze	40.1	35.3	24.6	Siemianowice Śl.	54.8	36.6	8.6
Rural communities				Świętochłowice	55.9	31.6	12.5
Bobrowniki	28.6	38.1	33.3	Tarnowskie Góry	23.5	30.0	46.5
Bojszowy	22.8	36.2	41.0	Small towns – under 20 thousand inhabitants			
Chełm Śląski	20.6	32.6	46.8	Bieruń	28.6	37.6	33.8
Gierałtowice	21.5	37.7	40.8	Imielin	14.7	22.9	62.4
Kobiór	2.7	8.8	88.5	Lędziny	26.8	34.2	39.0
Krupski Młyn	5.5	11.8	82.8	Łazy *	1.8	4.1	94.1
Miedźna	2.8	8.4	88.8	Miasteczko Śl.	5.8	11.0	83.2
Mierzęcice	22.8	43.4	33.8	Orzesze	12.9	24.4	62.7
Ornontowice	27.8	29.3	42.9	Pyskowice	21.4	28.5	50.1
Ożarowice	20.0	30.9	49.1	Radzionków	29.5	27.9	42.6
Pilchowice	2.2	5.4	92.4	Siewierz *	10.1	19.5	70.4
Psary	36.9	46.9	16.2	Sławków	15.6	25.1	59.3
Świerklaniec	14.6	27.4	58.0	Wojkowice	48.6	37.4	14.0
Tworóg	7.3	14.9	77.8	total			
Wielowieś	1.0	2.2	96.8	cities	37.1	31.1	31.8
Wyry	12.5	22.8	64.7	medium towns	30.8	31.8	37.4
Zbrosławice	15.6	29.0	55.4	small towns	12.7	19.3	68.0
* in the urban-rural communities of Łazy and Siewierz, the urban and rural parts were considered jointly				rural communities	13.1	22.1	64.8
				total	23.5	26.1	50.4

Explanation: in calculations of accessibility, only the stops with a total number of departures over 20 a day were taken into account

The condition of a 5-minute walking distance to the stop and the simultaneous condition of the offer level of over 200 departures daily on business days were only met in 7.2% of the Katowice conurbation area, which comprises 1/3 of the zone of good spatial accessibility to this service (7.2% out of 23.8%). As a result of an additional condition, in cities, the good accessibility zone decreased twofold (from 37.4% to 17.4%), in medium towns – threefold (from 30.8% to 9.8%) and in small towns and rural communities, it practically ceased to exist. The lowering of the threshold from 200 to 100 departures caused the change that the required conditions were met by not 7.2% but 11.8% of the conurbation, but it was still only half of the good spatial accessibility zone to the stops.

Interesting research on spatial accessibility, devoted exclusively to tram transportation in the area of the Katowice conurbation, was performed by Rechłowicz (2012), who concentrated on multi-family developments. In the research results, the author indicated four sections or areas, where over 90% of multi-family development is located in the range of the 500-metre equidistance from a tram stop. The sections, or areas of the network, are as follows: 1) from Ruda Południowa through Chebzie, Lipiny to Piaśniki and Łagiewniki, 2) the centre of Sosnowiec and Sielec, 3) from Bytom to Szombierki, 4) from Chorzów to Świętochłowice.

3. Time accessibility of town and community centres

The role of time in the transportation process is best described by the slogan "time is money". Time in transportation has economic and social values and as such is essential (Kubalski & Mazurek, 1968, p. 122). In investment projects in transportation, apart from benefits resulting from improving the natural environment and security, and with economic development of the region, the basic benefits result from a shortening of the time of transit (Wacławiak & Wolański, 2006, p. 94). Time is the element that might be valued economically – hence the frequently used notion of the value of time in analyses. Thanks to the shortening of the time of transit, additional extra time is gained and adversely – the lengthening of the time of transit forces generating the time at the expense of other activities. This refers to both passengers as well as service providers.

When evaluating the significance of the time of transit factor, it is necessary to include additional and subjectively perceived transit features, such as motivation, degree of compulsoriness and urgency of the journey, location of initial and final stops, and the route and conditions of the transit and costs, in their broad meaning, which include not only the financial cost of the service, but also benefits or losses resulting from lost or gained time, depending on the selected means of transport. The significance of time in transport is higher due to the increased pace of life. Transit time is the basic factor that decides upon the competitiveness of public transportation versus individual transport (compare: Molecki, 2006).

The time of transit consists of: 1) time of getting to the stop, 2) time of waiting for the ride (on the initial stop and during changes), 3) time of transit (joint for all means of transport), and 4) time of getting to the destination. The most essential phase of this cycle is the time of transit using one or several means of transport, while all other phases are subordinate and treated as auxiliary (Tarski, 1976, p. 141). Time of transit is a function of distance (between the initial and the destination stops) but it is also influenced by several elements resulting both from the specifics of public transportation as well as external factors. The most important are: technical characteristics of vehicles, number and location of stops, condition of road and track infrastructure, existence of solutions promoting public transportation vehicles and the human factor. Most of these elements may be shaped with the application of various administrative, legal or technical solutions, with appropriate funding within coherent transportation policies (Gadziński, 2010). The perception of time also depends on the distance covered and the conditions of transit (Rudnicki, 1999).

In the situation when accessibility equals the possibility of using diverse activities or functions (Taylor, 1999), and the time in transport is the moment when an occurrence took place, or is the period when a given process lasts, then time accessibility of public transportation will mean the possibility to use public transportation both in a given moment of time as well as in a specified period of time, i.e. in the expected or acceptable time of transit. Time accessibility is a consequence of not only the time of transit resulting from the distance covered, spatial arrangement and timetable of the transportation offer, but also the functional coordination of lines within specific routes and in transfer points.

Due to the complexity of the issue and vast research areas, time accessibility of public transportation was studied in two depictions only: the time of reaching the centre of a given community and the time of transit between community centres. In rural communities, the centre was considered as the village administrative headquarters. Due to the difficulty in expressing a precise depiction of both the time of transit and the time of wait at a stop resulting from the level of the offer, time accessibility of centres was examined with the use of the author's own indicator, based on the point and rank method. For every stop, both elements which are important in time accessibility were taken into account: the real time of reaching the centre from that place and the level of the offer measured by the total number of departures from the stop on a business day. Only direct connections were included.

Points for the time of transit were granted according to the following principles: up to 10 min – 5 pts, for each subsequent 5 minutes of the transit – 0.5 less, over 51 min. – 0.5 pts, for no direct connection – 0 pts. When calculating the time of transit, the fastest and the most functional connections were considered and the average value was included for both directions – to and from the centre, or to and from the headquarters of village administration. If you could only go in one direction from a stop, for the opposite direction, walking distance to, or from, another stop was allowed, up to 10 minutes, adding the time of walking to the average transit time. If the time of transit between specific lines varied, the most characteristic line for this connection was selected, taking the time of transit for the afternoon rush hours. Transit through another community was allowed on condition that it happened in a direct connection.

Depending on the total number of departures from a given stop, points for the time of transit were calculated according to the following formula:

$$Dp = \frac{t * k}{10}$$

where: Dp is the time accessibility of the community centre from a given stop, calculated in points, t – points for the time of transit, k – every 20 departures started in the range of up to 200 departures and every 33 departures in the range of 201 to 500 departures.

It was assumed that over 500 departures, the value of the "k" index is constant and equals 2.0. Therefore, a better offer may compensate for a longer time of transit. Stops in community centres, which were the destination points, were excluded from calculations and granted maximum possible points for this method, that is Dp_{max}=10. The acceptable level of time accessibility of a community centre from a given stop, assumed by the author, was half that amount, that is Dp_{acc}=5, which results from the principles of this index. This level is an arithmetic mean for the range of the index's variability. It is not possible, though, to keep both conditions simultaneously for all the stops in a community: a good offer and short time of transit to the centre. The index for time accessibility of a given community (Dcg) was calculated according to this formula:

$$Dcg = \frac{Dp_1 + Dp_2 + \cdots + Dp_n}{N}$$

where: Dp_1, Dp_2, ..., Dp_n – are time accessibility of a community centre from a given stop, calculated in points, N- number of stops within a community.

Simplifications introduced in the research, consisting of the inclusion of only those stops which have a direct connection with the centre, do not influence the results significantly.

Calculations made on the basis of timetables have revealed that for the area of the Katowice conurbation, the average value of the accessibility index to a community centre (Dcg) was 2.59. In the group of cities and medium towns, average values of the Dcg index were slightly higher – 4.03 and 3.50, respectively – than in the group of small towns and rural communities – 1.82 and 1.72, respectively. In terms of the Dcg index, the best time accessibility to the centre in cities was in Chorzów (4.99), among medium towns – in Czeladź (4.63), among small towns – in Radzionków (3.89) and among rural communities – in Kobiór (4.00). In the communities of Łazy and Miedźna, the value of the Dcg index equalled 0 due to the fact that public transportation there did not reach the centres of these communities. Centre accessibility was especially low in communities of a large area (e.g. Dąbrowa Górnicza, Jaworzno) and of an insignificant number of departures from particular stops (e.g. Łaziska Górne, Orzesze, Siewierz, most rural communities). The values of the Dcg index for particular communities are presented in Fig 2.

In neither community of the Katowice conurbation was the value of the Dcg index, that is the arithmetic mean of the Dp index value in the area of a community, higher than 5.0, which is the acceptable level of time accessibility to the centre indicated by the author. This means that in the area of the conurbation, with the exception of Chorzów (Dcg=4.99), in the scale of the whole community, fast transit to the centre with the simultaneous possibility of starting a trip without having to adjust to the schedule, was not theoretically possible.

The research on the time of transit between specific communities of the conurbation was conducted for business days, both for the communities with direct connections on public transportation and those where you may only travel with transfers. Due to the large scale of calculations, the research was limited to the time of transit only in the "centre to centre" relations. With such a vast area of research, this range of calculations accounted for 2209 combinations.

According to the assumptions, only the time of transfer was researched and not the total time of journey, which means that in calculations, the stages of getting to and from the stop and the time of wait to start the transit at initial stop were omitted. This does not include the omission of the time of wait at transfers, since they result from the level of the offer on particular routes and the time of moving between stops or stands. If a connection in a given direction required several stops, time of transit to the optimally located stop in relation to the centre was calculated, where the number of lines in a given route was the highest.

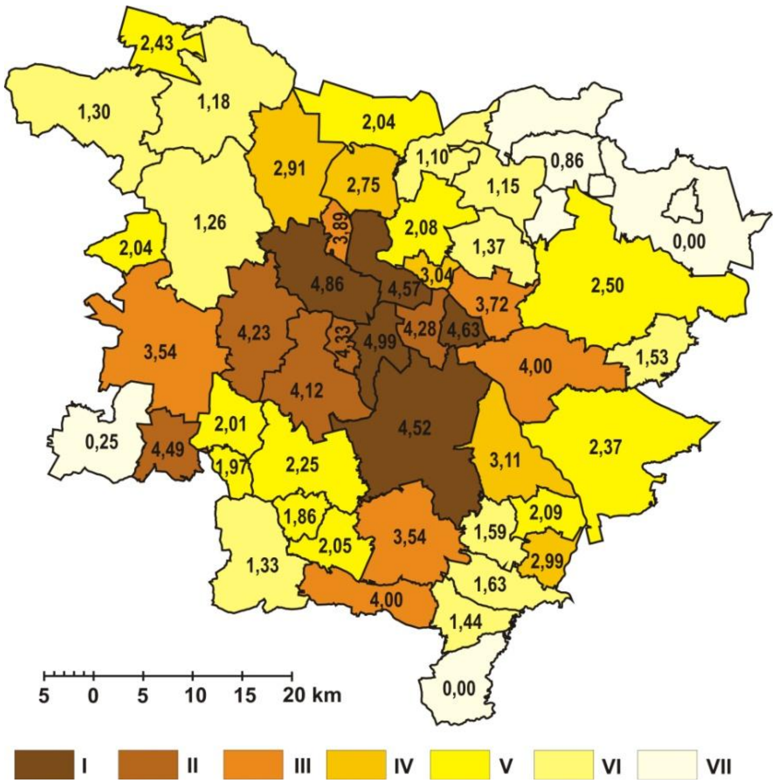

Fig. 2. Time accessibility of the community centres in the Katowice conurbation by Dcg index (own study)
Values of Dcg index: I – 4.51 and more; II – 4.01 – 4.50; III – 3.26 – 4.00; VI – 2.51 – 3.25; V – 1.76 – 2.50; VI – 1.01 – 1.75; VII – 1.00 and less

In the case of direct connections, the fastest and most functional connection between communities was taken into account. If the time of transit differed in particular parts of the day, the time of ride on business days in rush hours was assumed. In the case of connections requiring a transfer, the calculated value was not the exact time of transit, but only a value estimated on the basis of the total time of transit using direct connections and a statistical time of wait for the transfer. If there were several connections on some routes in a similar time, the fastest one was taken for calculations, not including slower connections that were overtaken. The time of wait was accepted as half of a module of average total frequency of connections on particular routes. An additional assumption was made that a person who was travelling, had average knowledge of the transportation network and all the transfers were done in the centres of cities, towns and villages with community headquarters. Exceptions were only made in several cases, where the move of the transfer outside the centre resulted in a significant shortening of the transit time.

The achieved results of the calculations have revealed that the real possibilities of movements in the Katowice conurbation are considerably lower due to the time of transit than those that theoretically result from the size of the network, which covers an area of almost 2.5 thousand km^2. It is a result of covering large distances with a means of transport that moves with a relatively low transportation speed. Even if the time of transit using public transportation between the centres of adjacent communities was only a dozen minutes, it was extended to almost up to 5 hours for the outermost communities of the research area.

Assuming the criterion of an average time of transit in the "there" and "back" routes between the centres of particular communities, transit up to 30 minutes was possible mostly between adjacent communities or those located in proximity (up to a dozen or so kilometres) and the time up to 60 minutes was the travelling time between several communities. Only in communities located in the central part of the conurbation, one may have transferred between over 10 communities in under 60 minutes. Therefore, on longer routes, transit time on public transportation created a serious barrier for mobility, the only alternative being having one's own car.

The best time accessibility in such a depiction was found in Katowice, where it was possible to access 9 communities in under 30 minutes and, under 60 minutes, to 21 communities. The opposite was in rural communities located on the outskirts of the conurbation, where in the isochrone of time of transit was over 3 hours, there were usually a dozen or so communities and in the extreme case – in Pilchowice – it was 31 communities. On comparing transit time for direct and transfer connections, a crucial influence of transfer on the lengthening of the transit time is apparent. It is a consequence of a statistically long wait for the possibility of continuing the journey. The possibility of choosing a faster connection in some cases, that reaches the destination using a longer route, does not, after all, have any influence on the shortening of the transit time, but it only shortens the time of wait. Using accelerated and fast lines definitely shortens the time of transit on longer routes.

A synthetic depiction of the issue of time accessibility in inter-community transits in the Katowice conurbation was realized in the form of a comparison of the average time of transit on public transportation in the "there" and "back" directions from the centre of a studied community to the centres of all the remaining communities (Fig. 3)

The shortest average time of transit to other communities on public transportation was observed in Katowice (67 min) whereas the longest was in the community of Pilchowice (194 min). A short average time of transit (under 90 min) was a feature of several other cities and towns located in the central part of the research area: Bytom, Chorzów, Piekary Śląskie, Siemianowice Śląskie and Sosnowiec. The shortest average transit time on public transportation to the centres of the remaining communities in the Katowice conurbation was typical for cities (88 min), in medium towns it was slightly longer (100 min), and the longest in small towns (129 min) and rural communities (142 min).

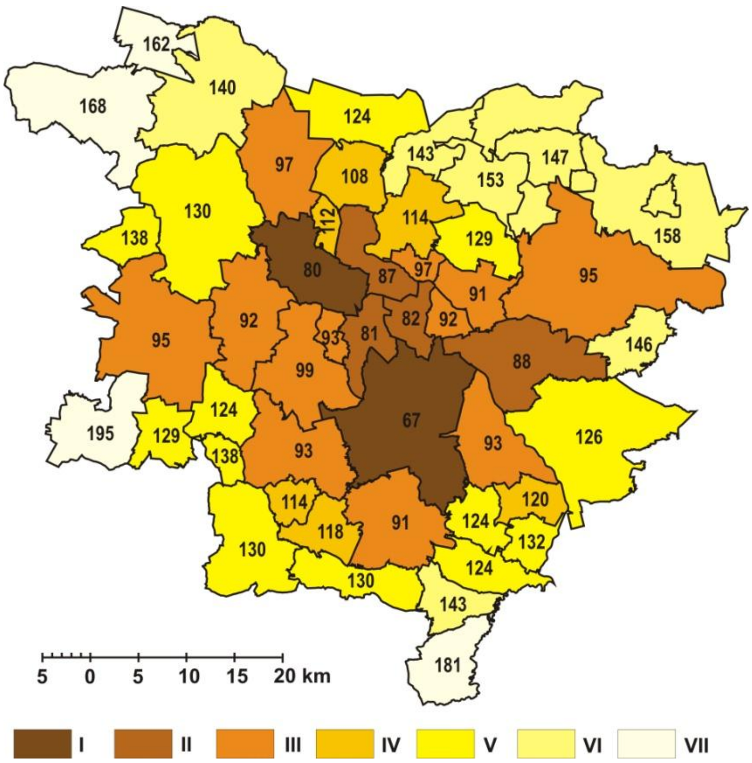

Fig. 3. Average time of transit to other communities by public transportation (in route „there" and „return")
in the Katowice conurbation (own study)
Average time of transit in minutes: I – 80 and less; II – 81 – 90; III – 91 – 100; IV – 101 – 120; V – 121 – 140;
VI – 141 – 160; VII – 161 and more

4. Network of community connections provided by public transportation

Transport serves three functions in an economy: consumption, production and integration (RYDZKOWSKI, 2005, p. 2). In public transportation, the integral function of transport is realized through the possibility of making transfers in a certain area. Transits made in transports are physical manifestations of relationships between settlement centres (DZIADEK, 1998) and their intensity reflects the strength of spatial connections that are present. The functioning of the conurbation, just like any other settlement system, is reflected in connections of various types between the elements of this system and one of them is the transportation connections (RYKIEL, 1981). Public transportation in the Katowice conurbation historically had and still has the inter-community character at present, which is why it is difficult to overlook this characteristic feature in the research.

Transportation connections between communities were examined on the basis of a scheduled offer, with the simplification in the form of this offer being the answer to the present needs for transits. Such research completes the picture of public transportation accessibility in the conurbation, pointing out the crucial feature that facilitates the possibility of movement, which is the directness of connections, preferred by passengers. To evaluate and compare the strength of inter-community connections realized by public transportation, a classical measure was adopted in the form of a number of inter-community connections. Such research for the area of the Katowice conurbation and with the use of an analogous measure was performed by RYKIEL (1981). With consideration to crucial differences in the offer level between business days and days off-work, an average number of connections for all days of the week was adopted.

The most spatially developed network of inter-community connections realized by public transportation was noted in Katowice, which had direct connections with 25 cities and towns and 6 rural communities of the conurbation. It is justified by not only the hierarchy of the city in the settlement system, but also by the size of the labour market. The relation of the number of workers to the number of inhabitants in Katowice was one of the highest in the conurbation (RUNGE, 2010). Among cities and medium towns of the conurbation, a spatially developed network of connections was present in Bytom, which has direct connections with 14 cities and towns and 6 rural communities and also in Gliwice, Ruda Śląska and Tychy. The analysis of the system of inter-community connections in many cases explains the cause of a considerable lengthening of transit time in inter-community relations on longer routes.

In the group of medium towns, the most spatially developed system of connections was a characteristic of towns, which were the headquarters of rural counties – Będzin, with direct connection with 10 cities and towns, 2 urban-rural communities and 4 rural communities and Tarnowskie Gory, with direct connections with 10 cities and towns and 9 rural communities, and also towns located in the central part of the researched area – Siemianowice Śląskie, Piekary Śląskie and Mysłowice. In the group of small towns, the most spatially developed system of connections was observed in Wojkowice and in the group of rural communities – the communities of Bobrowniki, Ożarowice, Mierzęcice and Świerklaniec. Spatially developed systems of transportation connections in smaller settlement centres come as an effect of an advantageous location in proximity to, or between, bigger towns. Then, routes of thoroughfare type from more distant areas, towards bigger towns, are led through such communities.

The most developed spatial connections in the Katowice conurbation were the connections of Katowice with Chorzów (801 connections), with Sosnowiec (574 connections) and with Siemianowice Śląskie (473 connections), Będzin with Sosnowiec (455 connections), with Dąbrowa Górnicza (442 connections) and Chorzów with Bytom (401 connections) and Świętochłowice (409 connections). The values of the number of connections given were average for all days of the week and in both directions. In all the cases, the most developed connections were based not only on bus transportation but also on trams, which proves the significance of trams in integrating the space of the Katowice conurbation (compare: DZIADEK, 1995).

The stage of development in spatial connections of particular communities of the Katowice conurbation was compared with the help of a total number of public transportation connections realized from a given community to the other communities, average for all days of the week. The highest total number of inter-community connections among cites was found in Katowice (4754 connections), among medium towns- in Będzin (2141 connections), among small towns – Wojkowice (638 connections) and among rural communities – Bobrowniki (651 connections). The lowest total number of inter-community connections among cities was found in Tychy (532 connections), among medium towns – Knurów (257) and Jaworzno (280), located on the outskirts of the conurbation. Detailed data for particular communities is presented in Fig. 4.

5. Accessibility of public transportation in the system of communities – a synthetic depiction

A comparison of public transportation accessibility in the system of communities was performed with the use of the quality classification method, on the basis of four, previously characterized measures: I – percentage participation of a community area in the 10-minute walking zone to a stop, with consideration of the minimal number of departures condition, II – time accessibility to the centre of a given community – calculated with the point and rank method, III – average time of transit on public transportation from the centre of a given community to centres of remaining communities, IV – total number of inter-community connections. Each of the measures was standardized by the reference of values for a given community to maximal values for the stimulants (features I, II, IV) and minimum for destimulants (feature III) of the research areas. The total of standardized values of measures was adopted as the indication of public transportation accessibility.

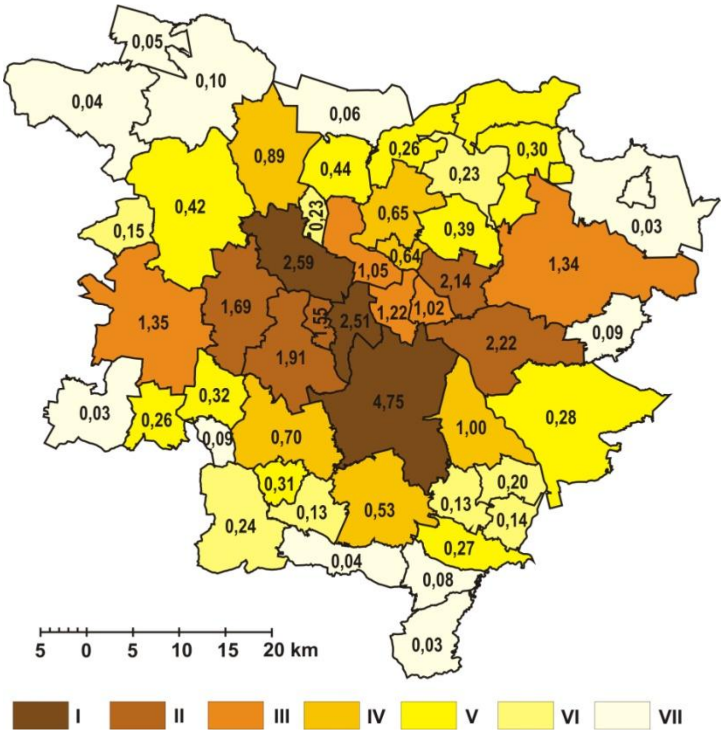

Fig. 4. The total number of inter-communities public transportation connections in the communities of the Katowice conurbation in 2008 average for all days of the week (own study)
The number of connections in thousands: I – 4.00 and more; II – 2.01 – 4.00; III – 1.01 – 2.00; IV – 0.51 – 1.00; V – 0.21 – 0.50; VI – 0.11 – 0.20; VII – 0.10 and less

The research conducted has revealed that the accessibility of public transportation created a concentric and centrifugal structure in the Katowice conurbation. The average value of the synthetic indicator that presented accessibility was 1.86, with the theoretically maximal value of 4.00. It was higher in cities and medium towns – 2.81 and 2.36 respectively, and lower in small towns and rural communities – 1.42 and 1.32 respectively. In cities, the best accessibility was in Katowice (3.62), the weakest – in Dąbrowa Górnicza (2.12); among medium towns – the best was in Będzin (2.90), the weakest in Jaworzno (1.64); among small towns – the best was in Wojkowice (2.38), the weakest in the urban-rural community of Łazy (0.49); and among rural communities – the best accessibility was in the community of Bobrowniki (1.83) and the worst in the community of Pilchowice (0.48). Detailed values of the public transportation accessibility index are presented in Fig. 5.

Considering accessibility in the system of communities belonging to particular organizers of public transportation, differences between particular organizers were apparent. The average value of the accessibility index in communities, which relied on the Municipal Transportation Association GOP for public transportation in Katowice amounted to 2.17, on the Urban Transportation Board in Tychy – 1.66, on the Public Transportation Company in Jaworzno – 1.63, on the Inter-Community Association of Passenger Transportation in Tarnowskie Gory – 1.45, and on the Automobile Transportation and Shipping Company in Oświęcim – 1.19. Nevertheless, it is difficult to prove an unambiguous relationship of the influence of organizational divisions on the accessibility of public transportation due to the fact that all organizers, with the exception of the KZK GOP, were active in areas with a much lower population density, which determines the level of public transportation development. In practice, that means that the demand for such a type of transport is lower. The dependence between the population density in particular communities of the Katowice conurbation and the value of the synthetic index of public transportation accessibility, statistically confirmed with the regression equation, is presented in Fig. 6.

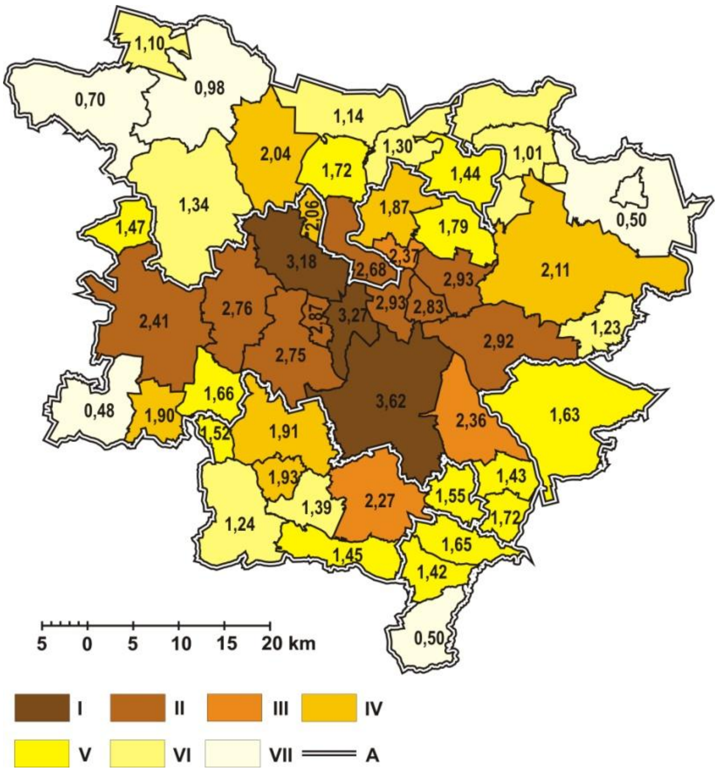

Fig. 5. Accessibility of the public transportation in the communities of the Katowice conurbation (own study)
The sum of standardized values of indicators: I – 3.01 and more; II – 2.61 – 3.00; III – 2.21 – 2.60; IV – 1.81 – 2.20; V – 1.41 – 1.80; VI – 1.01 – 1.40; VII – 1.00 and less; A – division of the organizers of the public transport

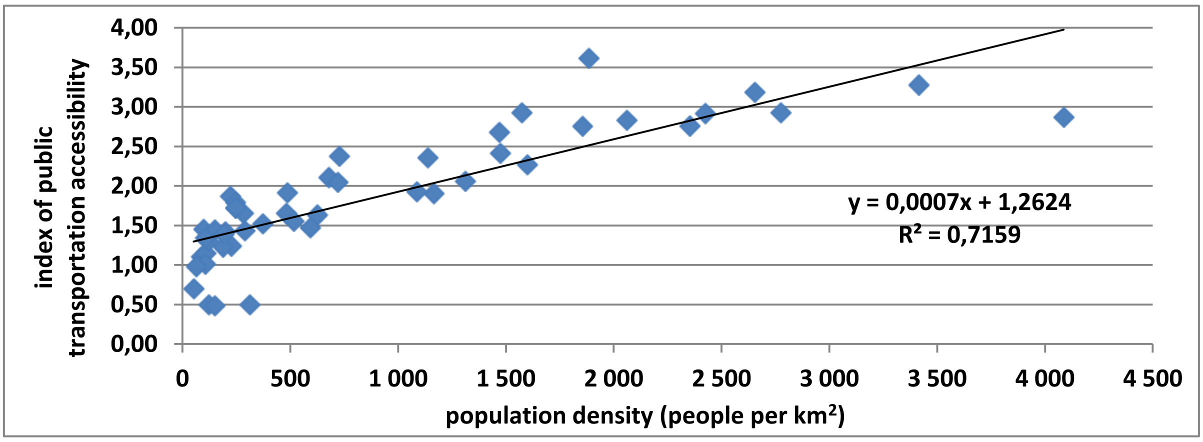

Fig. 6. Dependence between population density and public transportation accessibility in the communities of the Katowice conurbation (own study)

Research conducted has revealed that treating the issue of public transportation accessibility only in categories of spatial accessibility to the service itself may lead to the wrong conclusions. Good accessibility to this kind of transport may only be present with the co-existence of all interlinked elements: 1) short walking distance to a stop, 2) short wait to start the journey (which is a derivative of a good offer) and also 3) relatively short time of transit, not too different from a car ride. Whilst, despite a developed network of public transportation connections that is present in the area of the Katowice conurbation, in many cases it is not possible to use such kinds of transport for regular transits for further distances (e.g. to commute to work) due to the fact that the time lost on transport exceeds the value that a passenger may devote daily to transits.

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