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## AN ANALYSIS OF TRANSPORTATION TIMES AND THE LOADING OF THE SELECTED LINE OF URBAN COMMUNICATION IN RZESZÓW

As part of this article, on the basis of data obtained from the test on public transport functioning in Rzeszów, it has been decided to analyze the transportation times and the loading of the 0B transportation line in particular hours and days of the week of the selected period of time.

**Keywords:** public transport, travel times, transport line, bus stop.

**Introduction.** Travelling is an integral part of the daily activities of people in order to perform certain activities. The city is a specific area, often characterized by high-density housing with heavy transport needs reported by its users. For most of these requirements, it is necessary to meet the transport needs, and in the case of a passenger transport such an operation should be determined as the concept of transportation needs [3]. The continuous development of urban areas causes urban sprawl and an increase in the number of its users, and subsequently an increase in the intensity of different needs. The city transportation system is a kind of "circulatory system". It allows the daily functioning of the city, the movement of people, goods or information exchange. Improperly functioning communication system causes a number of difficulties and delays in meeting the needs and performance of its duties. Therefore, it is essential to supervise traffic constantly for the optimal management of the areas which show the need to repair or improve the currently prevailing urban logistics solutions.

As part of this article, on the basis of data obtained from the test on public transport functioning in Rzeszów, it has been decided to analyze the transportation times and the loading of the 0B transportation line in particular hours and days of the week of the selected period of time.

Public transport in Rzeszów. Rzeszów is the largest city in the south-eastern Poland, with an area of 116.32 km<sup>2</sup>, with a population of 184,106 inhabitants [4, 5]. The city is the capital of the Podkarpackie Province and the major economic, commercial, industrial, cultural and academic center. The city is situated at the crossroads of important traffic routes, close to the borders with Slovakia and Ukraine. Rzeszów has a clearly shaped zone of downtown development, with a radially and coaxial system, and the visibly distinct industrial and residential districts. The city is divided into 29 settlements, the most populous one is Nowe Miasto - 14 962 inhabitants, while the least people live in Miłocin settlement - 864 [4, 5]. The population density in Rzeszów is among the lowest in Poland, among the large cities. In the city there are a lot of recreational and green areas. The left-bank part of Rzeszów has a more compact buildings, which are mainly residential.

In December 2014 Rzeszów public transport was composed of 46 regular bus lines, 3 special lines and 3 night lines. The line 0B, analyzed in the paper, as one of the six belongs to the priority line, whose service frequency at peak times is 10-15 minutes. Additionally, in the system of public transport one can extract the basic lines which run every 20-30 minutes and complementary ones. Rzeszów public transport is characterized by two peaks - in the morning from 6:30 - 8:30 and in the afternoon from 14:00 - 16:00. The entities responsible for organizing public transport and service delivery are presented in table 1.

Tab. 1. Tasks of the selected entities in the public transport market of the City of Rzeszów.

Entity	Tasks
Public Transport Authority in Rzeszów	Organization of public transport
MPK – Rzeszów Sp. z o.o. (City Public Transport)	Providing services in public transport

In the area of the city the communication lines of other carriers run as well. However, they focus solely on getting passengers to Rzeszów and it can be assumed that they do not take part in meeting the needs of transport in the city.

Characteristic of the tested line. The concerned line is one of the most important public transport lines in Rzeszów. Its course is shown in figure 1. This line is characterized by a circular motion around the center of the city. Its beginning and end are located adjacent to the main railway station. Along its route there are the main shopping centers of Rzeszów, two universities with student housing estates and the largest industrial plant. On the route of the line there are 19 bus stops. The list of the bus stops is shown in table 2.



Fig. 1. The course of the 0B line in the city along with the bus stops located within its route

Tab. 2. The list of bus stops with numbers assigned to their names.

No. of the bus stop	Bus stop name	No. of the bus stop	Bus stop name
4B	Pl. Kilińskiego 01	24A	Powst. Warszawy Shell 03
2C	Pl. Wolności 01	26A	Powst. Warszawy Church 01
84A	Rejtana Merkur Market 01	14A	Dąbrowskiego The Institute of Music 07
144A	Rejtana/Kustronia 03	12A	Dąbrowskiego Pavillions 03
82A	Rejtana University 05	10A	Dąbrowskiego The Court House 01
80A	Rejtana Millenium Hall 07	8B	Lisa - Kuli Roundabout 02
78A	Rejtana Nowe Miasto 09	6B	Cieplińskiego 01
60A	Powst. Warszawy Tesco 13	4C	Piłsudskiego Voivodeship Office 03
58A	Powst. Warszawy Nowe Miasto 11	2B	The Main Railway Station 04
56A	Powst. Warszawy Students' Dormitory 09		

The considered line is characterized by a unidirectional traffic. The opposite direction is supported by the 0A line. Both lines are serviced mostly by modern two-axle low-floor buses.

Findings analysis. In the first instance, on the basis of the available data the total number of people getting on and off at the bus stop and the number of passengers carried between stops have been set. The results of these operations are shown in the graphs in figures 2 and 3.

The courses presented in figures 2 and 3 relate to a single selected course. For more information on the distribution of the stream of passengers throughout the day, the calculations have been performed for all courses and then they have been merged for individual days. In figures 4 and 5 the graphs showing the number of passengers transported in individual courses have been presented. The data in figures apply only to regular courses, i.e. those which are implemented by a bus from the morning until the evening. The figures do not include additional courses carried out during peak hours in the morning and in the afternoon.

In the second stage of the research it was decided to analyze the travel times throughout the whole course of the same line. For the research 10 satellite receivers with integrated GSM module, which send data to the main server [1, 2] were used. The data on the parameters of a single vehicle movement were recorded in text files for each working day. The worked data from the period of March 29 - April 16, 2014 have been presented in figure 6. For the data processing the program written in Matlab has been applied. The points visible in the figures represent individual travel times throughout the route of a length of 9.2 km.

For comparison of journeys times carried out during working days and weekends the appropriate polynomial approximation was conducted. The degree of the polynomial was selected as a result of repeated attempts. The primary criterion in the selection was to achieve the best fit curve. The resulting lines are soothing and omit points which significantly deviate from the course due to random cases. The courses comparing travel times on weekdays are shown in figure 7.

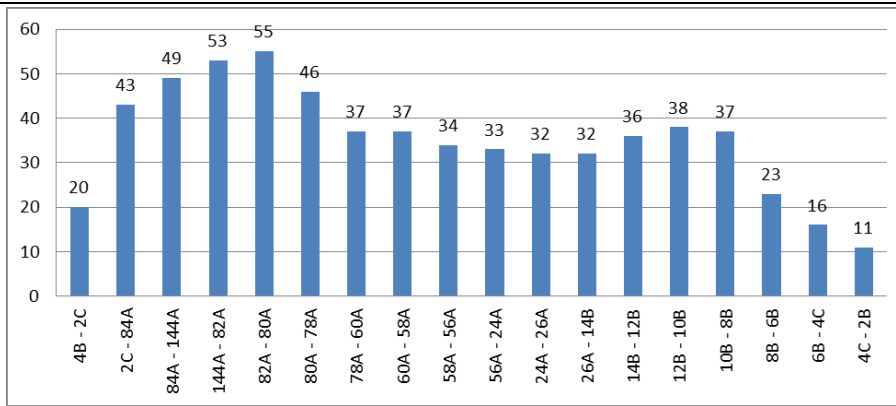


Fig. 2. The number of people on the bus in the “between-bus stops” course of the 0B line for the course starting at 13:49 on 18.11.2014

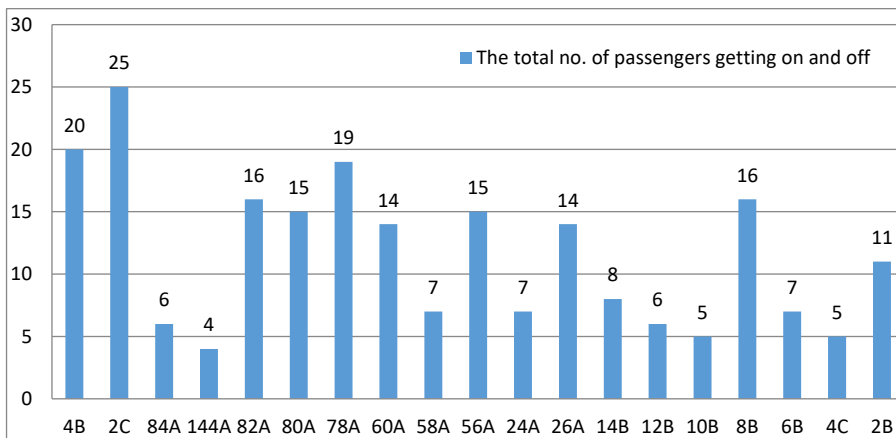


Fig. 3. The comparison of the number of people getting on and off for the 0B line for the course starting at 13:49 on 18.11.2014

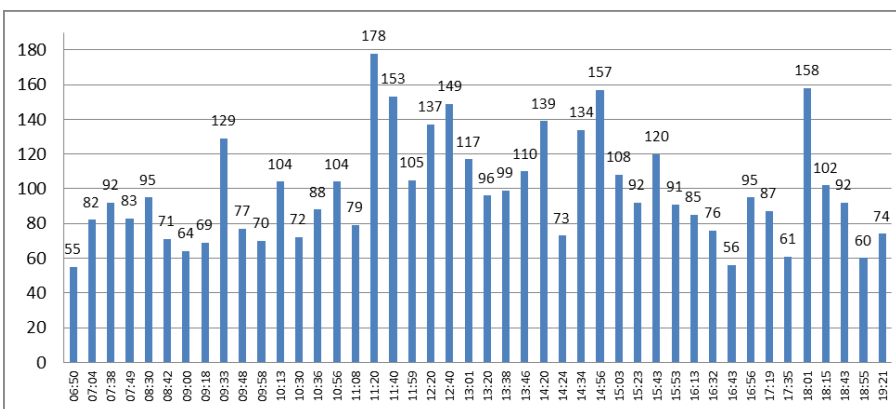


Fig. 4. The number of passengers carried on 18.11.2014 by the 0B line

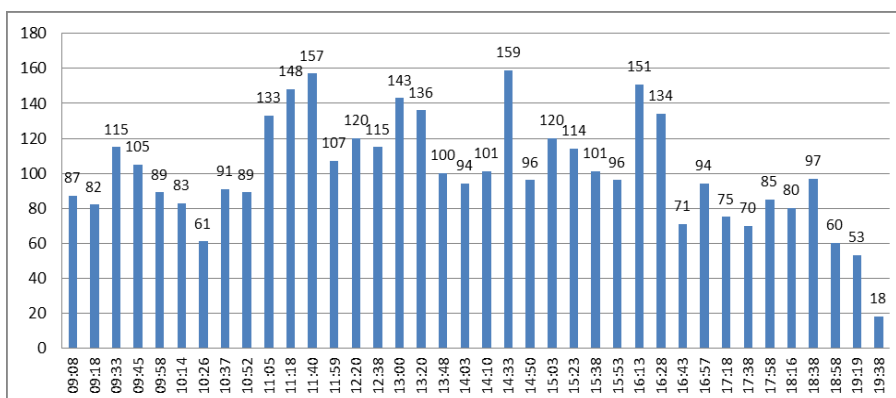


Fig. 5. The number of passengers carried on 19.11.2014 by the 0B line

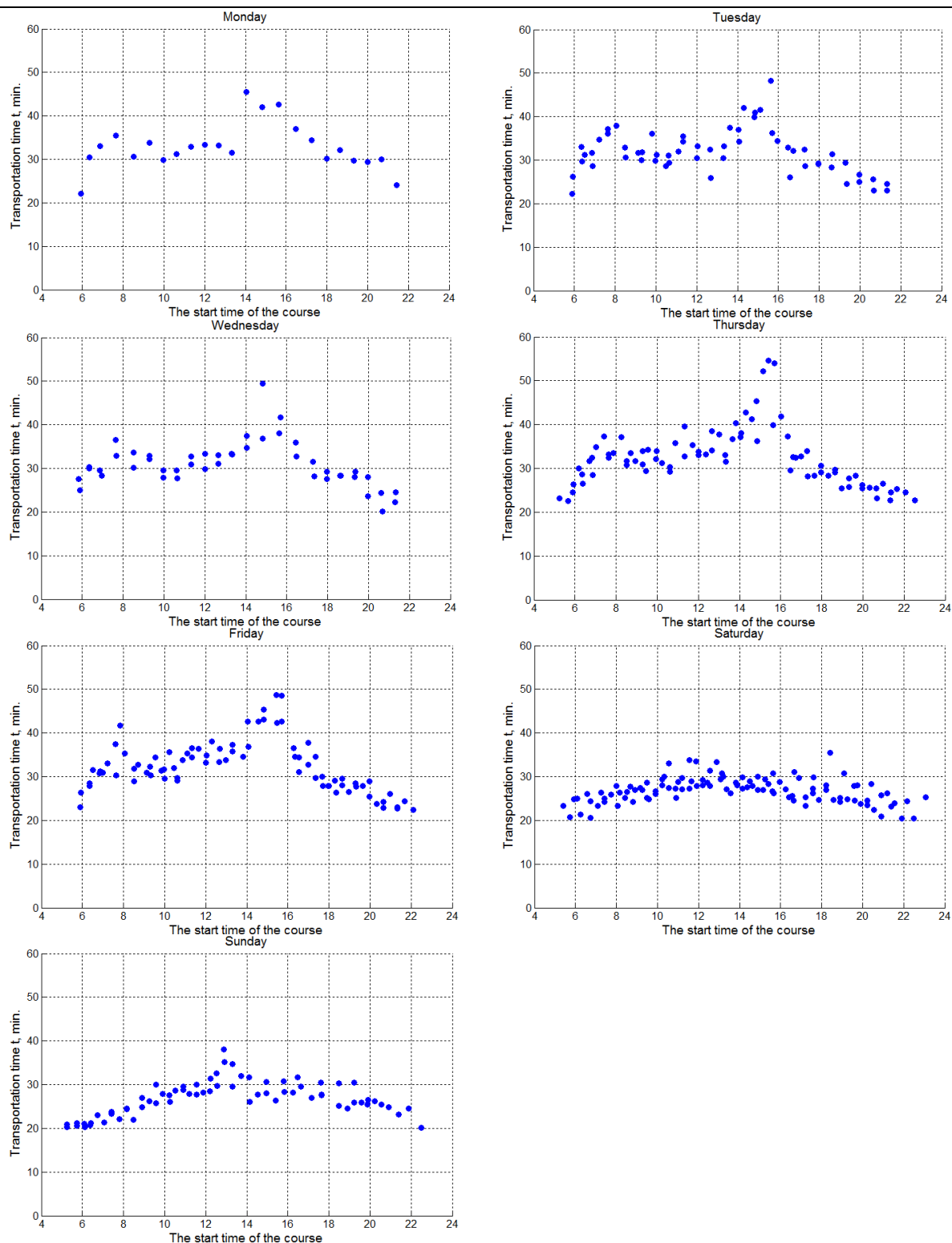


Fig. 6. Travel times across the whole route of the 0B line in each days of the week

In case of weekdays the most of the travel time is in the range between 30 - 40 minutes. There are two peaks. The first one is between 7:00 and 8:30. In this range, the average travel time reaches the value of 35 minutes, and rarely exceeds 40 minutes. The second peak is between 14:00 and 16:00. Here, depending on the day of the week, the average travel times range from 37 to 44 minutes. The maximum travel times reach the value of 55 minutes. This applies especially to Thursdays and Fridays. In these days and also on Mondays the travel times at the afternoon peaks are greater by about 5 minutes. The courses of travel times for weekends are shown in figure 8.

Saturday and Sunday are characterized by smaller differences. Most of the travel time is in the range of 25 - 33 minutes. The maximum travel time values different for the working days are between 12 and 2

p.m. But there is no significant deviations. Assuming that during the working days the travel time amounting to 25 minutes around 6 o'clock in the morning and 9 o'clock in the evening is the minimal time - the basic the bus can achieve for the set route, then in the morning peak time there is an increase of 40%, and in the afternoon of 80%. In absolute terms it accounts for 10 and 20 minutes. During the weekends these differences are much smaller and do not exceed 30% assuming the travel time of 23 minutes on Saturday. Sunday morning is characterized by even lower average travel time in the morning. Here, the time is almost 20 minutes. With a route length of 9,2 km it gives the average speed of about 27 km/h.

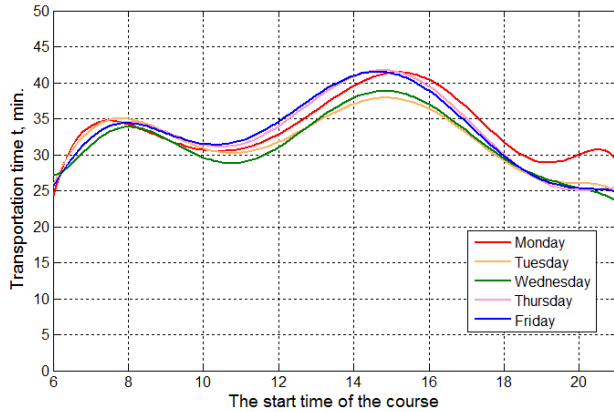


Fig. 7. The comparison of travel times during working days of the week

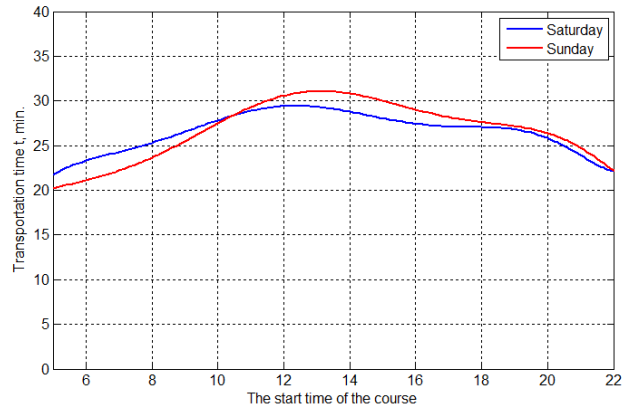


Fig. 8. The comparison of travel times during weekends

**Conclusions.** The study framework, where an analysis of more courses was done, allows to draw from two groups of proposals on the number of passengers. The first relates to the loading of individual courses. Maximum passengers loading does not coincide with the peak hours of travel times. Between courses there is considerable non-uniformity in the passengers loading. The observed non-uniformity may have three reasons. The first is the overlap of the lines following the same section of the route. The second reason may be the result of significant delays resulting from the random cases and traffic. In the last part of the research regarding the number of passengers it should be considered if a constant supply of travel capacity is properly correlated with the changing needs. In the case of the second group of proposals concerning the loading of individual bus stops, one should consider the introduction of changes to skip the bus stops which are not popular and to establish in this place the stops on demand. This issue requires further research, where one should also check the other lines exercising their routes on common parts with the 0B line.

Rzeszow as other cities of similar population records the declines of passenger transport by public transport. One of the main reasons is an increase in the number of vehicles and the degree of saturation of these vehicles. The increase in the number of vehicles and the degree of saturation is the effect of the deterioration of traffic conditions at selected times of the day. Travel times in the peak hours increase from 40 to 80%. This is particularly evident in figure 7 which compares travel times on working days of the week. This situation is a significant nuisance for the residents of the city. Separation of the respective lanes and preference of public transport will allow an increase in average speed and the reduction of the travel time of buses. Having a choice between being stuck in a traffic jam in a car or travelling faster by means of public transport, a significant number of people will surely return to the latter option. Another factor which induces people to use public transport is an increase of comfort during the travel. New means of transport purchased in recent years, have air conditioning, wide doors and low floor.

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**Смешек М., Добжанская М., Добжанский П. Анализ времени перевозки и загрузки выбранного городского маршрута в г. Жешов.**

В рамках этой статьи, на основании данных, полученных в ходе тестирования работы общественного транспорта в г. Жешове, было проанализировано время перевозки и загруженность транспортного маршрута 0В в отдельные часы и дни недели выбранного периода времени.

**Ключевые слова:** общественный транспорт, время в пути, транспортный маршрут, автобусная остановка.

**Смешек М., Добжанська М., Добжанський П. Аналіз часу перевезення та завантаженості обраного міського маршруту в м. Жешов.**

В рамках цієї статті, на підставі даних, отриманих в ході тестування роботи громадського транспорту в м. Жешові, було проаналізовано час перевезення і завантаженість транспортного маршруту 0В в окремі години і дні тижня обраного періоду часу.

**Ключові слова:** громадський транспорт, час у дорозі, транспортний маршрут, автобусна зупинка.

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