Abstract
The paper focuses on the issue of transport congestion, which is becoming an important and significant phenomenon in rapidly developing cities, especially in those, whose area, along with the number of inhabitants, is increasing due to absorption of surrounding small towns into the cities. Congestion has started to play a significant role in the life of Rzeszow – the fast developing capital of Podkarpackie voivodship, located in the south-eastern part of Poland. With reference to the transport system, the congestion impacts the city significantly, being a source of many problems. The aim of the paper is to indicate the consequences of congestion for the inhabitants. The empirical part of the paper presents the findings of an analysis of traffic in ten biggest Polish cities. Those findings will constitute the point of reference for the transport congestion in Rzeszow. Moreover, the paper presents the findings of the research conducted by the authors of this paper among the inhabitants of Rzeszow on their opinion on transport system in the city, road congestion and traffic. The respondents expressed also their opinion on actions taken by local authorities in order to limit congestion in the city. Conclusions derived from the research may be useful (provided that the local authorities take them into account) to limit the congestion in the city.

Keywords: logistics, traffic congestion, Polish cities

1. INTRODUCTION
More and more urban centers are struggling with the effects of transport congestion. Similarly, large cities in Poland, among which is Rzeszow – a strongly growing city in the south-eastern part of the country, are not free from this negative phenomenon.

Inefficient transportation system in any territorial unit is a barrier to proper functioning of a large urban agglomeration, as well as to its development. Therefore, it is important to diagnose the extent of congestion occurring in particular cities, as well as its consequences for them. It is also important to identify and implement actions that will allow to reduce the scope of this phenomenon.

In order to sustain the dynamic growth of the city, Rzeszow authorities have expanded its administrative boundaries (in total of the area of 63 km2) six times since 2006. This contributed to an increase in the number of residents who have become more and more mobile. This phenomenon, as well as many others (such as the increased flow of goods within the city), is leading to block the transport system of Rzeszow, which occurs more and more frequently. The ability to reduce the congestion may therefore be a key factor in the development of the city.

2. THE PHENOMENON OF TRANSPORT CONGESTION – A MEANING AND ITS CONSEQUENCES FOR A FUNCTIONING OF CITIES
The term “congestion” is derived from Latin and means aggregation or accumulation. The analysed phenomenon is multidimensional and the literature on the subject defines it in many different ways. In the context of the deliberations which were carried out in this paper, it is worth quoting a general definition of congestion and selected approaches considering transport dimension.
Congestion in general is defined as a situation in which more than one customer applies for a certain good, which cannot be provided as separate units. Thus, congestion is usually associated with public goods commonly consumed. Congestion occurs only in the business in which a buyer or user of specific goods spends certain resources in order to obtain them. The amount of these resources consumed per unit of a good or its quality must be strictly dependent on the time of acquisition of such good. This situation most often occurs in the transport, where increased traffic and traffic jams are signals indicating that different needs of users compete for limited road capacity [1].

Transport congestion – in the simplest approach - can be defined as a level of traffic in which an average speed of vehicles is lower than the minimum average speed that is still possible in free traffic flow [2]. Considering slightly extended definition, traffic congestion may be described as a situation when many vehicles on the same stretch of road or in a town center cause congestion, and in consequence, lead to a decrease in the speed of driving, frustration of drivers and excessive consumption of fuel, as well as emission of vehicle exhaust fumes polluting the atmosphere – hence why traffic congestion is seen as an environmental evil which has to be restricted [3].

Congestion observed today can be classified into two types - recurrent and non-recurrent. Recurrent traffic congestion is mainly caused by the increasing traffic demand (related to economic growth and the increasing need for urban mobility). The non-recurrent traffic congestion is caused by events that occur on the road, such as, among other things, car accidents, inclement weather and roadworks. Thus, non-recurrent traffic congestion caused by the roadworks activities may constitute a large portion of the total traffic congestion. According to the Federal Highway Administration (FHWA), roadworks account for about 10% of total traffic congestion in the United States. In the case of Germany, non-recurrent traffic congestion caused by roadworks amounts to 31% of the total traffic congestion [4].

Transport congestion has effects in many areas, which severely disrupt the functioning of the city and its inhabitants. The most visible and direct effect of the analysed phenomenon is extended journey time that causes economic losses for road users. Additionally, there are increased costs of the fuel that is used, and excessive wear and tear of vehicles. There are also other direct costs resulting from an increased risk of collision and the associated disadvantages (mainly increased stress for drivers). Congestion raises the costs of some services (e.g. those provided by taxi drivers), as well as extends the time of delivery of the goods (the latter necessitates maintaining an increased level of stock). Moreover, pollution and climate change, which result from an excessive fuel consumption as compared to the optimal conditions, are yet other problems that belong to a very important group of the negative effects [5].

Transport congestion concerns almost every developing city, as it is not only the problem of large cities or urban agglomerations. It occurs also in many smaller cities, mostly as the result of increased transit traffic.

3. RZESZOW TRANSPORTATION SYSTEM AND A LEVEL OF TRANSPORT CONGESTION IN THE CITY IN COMPARISON TO THE BIGGEST POLISH AGGLOMERATIONS

Rzeszow, with a population of more than 180,000, is the largest city in south-eastern Poland, and also the capital of Podkarpackie voivodship. The city is an important transport hub, located about 90 km from the borders with Ukraine and Slovakia. Within the city two international routes cross with each other – the east-west E-40 route (from Dresden to Lviv and Kiev) and the north-south E-371 route (from Gdansk to Slovakia). Also, national roads cross in the city - No. 9 (which is part of the E-371) and No. 19. The total length of roads in the city is 444.8 km (including national roads - 27.0 km, provincial roads - 5.1 km, district roads - 127.7 km, municipal roads - 122.0 km, internal roads - 163.0 km) [6]. In the vicinity of Rzeszow there will run the A4 motorway (which is a part of the E-40 route), whose launch was planned for mid-2012 (but due to the problems with contractors, the completion date of particular motorway stretches located around the capital of Podkarpackie voivodship has been postponed by a few months).
Traffic congestion is extremely difficult to measure accurately because it constantly changes across space and time. The level of congestion varies widely among different locations and at different times of the week or time of the day, according to unpredictable local circumstances (e.g. variations in weather, accidents, roadworks and other incidents). There is no simple way to aggregate these variations in order to measure a single “average degree of congestion” in the entire region for: a given hour, day, week, month, or year [7].

The phenomenon of congestion occurring in the largest Polish cities is analyzed in the reports published every few months by a portal Korkowo.pl. A statement, which appeared in December 2011, presented an average speed of movement on roads of ten large cities. The calculated speed was based on the rate of several thousand vehicles drive (the analyzed data were received from GPS devices). Within a 2 km radius from each city center, the speed at which drivers moved was analyzed in regard to all the streets, and at a distance of 2-5 km from the city center, only main commuting routes were subject to this analysis.

In 2011, Rzeszów was one of the most crowded cities, where an average travel speed in the center did not exceed 19 km/h - both in the morning and evening rush hours (Tab. 1). Due to this fact, Rzeszów was considered, next to such large urban areas as Warsaw, Poznan and Wroclaw, one of the cities with the lowest rate of movement. In a published report Cracow was the city with the least congestion – regarding a 2 km radius from the city center. A slightly higher speed rate was observed at a distance of 2 to 5 km from the city centers. In this case, Rzeszów was among the cities of low congestion (over 26 km/h), together with: Bydgoszcz, Gdansk, Cracow and Lodz.

<table>
<thead>
<tr>
<th>City</th>
<th>at a distance of 0-2 km from the city center</th>
<th>at a distance of 2-5 km from the city center</th>
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<tbody>
<tr>
<td></td>
<td>Average speed 6.00 am-9.00 am (km/h) average speed 4.00 pm-6.00 pm (km/h)</td>
<td>level of congestion</td>
</tr>
<tr>
<td>Bialystok</td>
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<td>Bydgoszcz</td>
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<td>Poznan</td>
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<td>Szczecin</td>
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<td>Warsaw</td>
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<td>Wroclaw</td>
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The level of congestion: ≈ ≈ ≈ - high (0-19 km/h), ≈ ≈ - medium (20-25 km/h), ≈ - low (26 km/h and more)

Source: [8]

On the basis of the average speed which was calculated during peak hours at various distances from the city centers, a ranking of the cities with the lowest traffic speed was prepared. The following cities at the top of the ranking were: Wroclaw (20.25 km/h), Warsaw (20.50 km/h), Poznan (21.15 km/h), Rzeszów (22.75 km/h).
km/h), Szczecin (23.00 km/h), Gdansk (24.00 km/h), Bialystok (24.75 km/h), Lodz (25.00 km/h), Bydgoszcz (25.5 km/h), Cracow (32.25 km/h) [8].

The quoted ranking shows that Rzeszow is one of the most congested cities at the peak hours. However, it is important to emphasise that a number of roadworks and road investments have been started lately in the city, which caused increased congestion and slowed down the traffic speed. When the investment are completed, the transport system in the capital of Podkarpackie voivodship will improve.

4. TRAFFIC CONGESTION IN RZESZOW IN RESPONDENTS’ OPINION

In order to become acquainted with the opinion of Rzeszow residents and people commuting to Rzeszow on selected issues related to the traffic congestion in the city and actions taken by local authorities to improve the functioning of transport in 2012, primary research was conducted using standardized questionnaire. 185 people were included in the examination. A large group of respondents were aged between 26-35 (they accounted for 45% of respondents), almost one third of respondents was between 36 and 45 years old. The vast majority of respondents reach a place of work or study by car (67%), every fifth on foot, and one in ten uses public transportation. A small group of respondents also pointed to other modes of transport, including train or bicycle, with every fourth respondent getting to work using at least two means of transport (or combining them - for example, a car and a bus or alternatively, for example, a bicycle or a car).

As few as 3% of respondents declared that their commuting time was not longer than 5 minutes – whereas similar number of people indicated that they commute to work in above an hour. Frequently, a commuting time indicated by the respondents was included in the range of 11-20 and 21-30 minutes (27% and 28%, respectively). Furthermore, for the same group – 14% of commuters, the time needed to get to work equals to less than 10 minutes and from 31 to 40 minutes. It is worth mentioning that as many as 76% of respondents said that they are stuck in traffic while commuting to work (a declared duration of waiting in the traffic varied and it was encompassed within the range from 5 to 40 minutes).

The vast majority of respondents thinks that the traffic congestion is a problem in Rzeszow, 83% indicated this answer (Fig. 1). Only 6% of them says that the city does not have to deal with the problem of too congested roads, and almost every tenth respondent has no opinion on this matter.

Although the respondents perceive Rzeszow as the city where congestion is a problem, if compared to other big Polish cities, they find Rzeszow as the city with an average traffic congestion – almost a half of the respondents has this opinion (Fig. 2). For 37% of respondents streets in the city are more congested than in other big cities, and only 6% of them perceive Rzeszow as the city with very high traffic congestion.
The evaluation of the level of traffic congestion in Rzeszow is reflected in the respondents’ opinions concerning investments that must be made by city authorities in order to improve transport and reduce traffic congestion. Only 12% of respondents said that traffic jams, in relation to other urgent issues that require investments and solutions in Rzeszow, pose the biggest problem. The vast majority of respondents (71%) sees this issue as a “rather serious problem” and every tenth of them believes that the traffic jams are rather neutral issue in the context of other problems (Fig. 3).

In response to the growing problems of transport congestion in Rzeszow, the city authorities in order to improve the flow of the cars through city roads have been pursuing a number of investments for years. Most of the road investments are co-financed by the European Union. In the last few years, among projects implemented with the financial support of the European Union there are: a connection of two national roads (No. 9 and No. 19) and a construction of the northern ring road, which will connect the city to the future S-19 express road and the A-4 motorway. Moreover, some of B-roads in Rzeszow and A-roads around the city were rebuilt and modernized in order to meet the European Union requirements. One of the most significant initiatives is a project called: “Building a system integrating the public transport of Rzeszow with the area around the city” with a value of over PLN 415 million. The preparation and implementation of the project has been planned for the years 2008-2014. The project includes, among other things, a design and implementation of “Integrated Traffic Management and Public Transport System” controlled by IT infrastructure. It has been planned to purchase new buses, adjust and increase functionality of bus stops and conversion of some roads and crossings crucial for public transport.

In order to improve public transport in the city and encourage inhabitants to commute by it instead of private cars, bus lanes were marked on some of the city roads. Furthermore, a PLN 16 million worth of investment,
which has been planned for the years 2010-2014, “The development of intelligent road transport system in Rzeszow”, is currently being implemented. This investment is a continuation of a previously launched project “Building a system integrating the public transport of Rzeszow with the area around the city”. It is planned to install 60 passenger information boards (the boards show current information on next few arriving buses at the bus stop), 50 e-kiosks “Public Passenger Information” (they help passengers to check on timetables and possible connections in public transport in the city) and 5 Weigh-in-Motion scales at the main entrance roads (it is a scale that measures weight of vehicles coming into the city).

Some of the investments have been already implemented, some are in the process of implementation. Respondents declared that they have noticed actions taken by the authorities of Rzeszow to improve transport system in the city (37% gave that answer), but simultaneously, almost every third said they have not notice any actions taken in order to improve the functioning of transport and limit transport congestion. Similar group (32%) has no opinion on that issue.

Among the most frequently mentioned actions which respondents indicated as examples of noticeable investments in the city there were: road works related to the improvement and reinforcement of road surfaces, widening of roads, repair of intersections and pavements, synchronization of traffic lights, installation of digital counters at the traffic lights, which display the time remaining to the light change, sectioning off the part of roads for bus lanes, building footbridges above the most congested roads, which enable pedestrians cross safely, purchasing new buses for public transport, increasing the speed limit on some roads, constructing roundabouts that allow for a collision-free motion of vehicles and bicycle rentals.

Respondents also pointed to additional actions that they believe should be taken in the future to further reduce traffic congestion in the city. Among the most common response emphasized by respondents there were giving the ring road for the use as soon as possible and banning transit for lorries and other big vehicles through the city. Moreover, respondents emphasized necessity of encouraging commuters to use of public transport more frequently (by taking some initiatives, for example: introduction of universal tickets for all means of public transport, lower prices for tickets, adjusting connections between different bus lines and modernization of bus stops). In addition, respondents stressed the need for better schedule of road works – including carrying out works at night (according to them carrying out repairs on a few crucial roads in the same time should be avoided due to the fact that such situations cause increased transport congestion and traffic jams), as well as the respondents suggested other solutions which might help to limit transport congestion, i.e. building a tramway track, greater use of the railway infrastructure that exists in the city, reducing traffic lights, increasing the number of bike lanes, constructing a new bridge over the Wislok river and establishing paid parking zones in the city center. Furthermore, respondents think that there should be more campaigns promoting cycling and also more car parks should be built both in the city and in the suburbs (in this second case it is important that the car parks are connected with bus lines driving to the city).

Many of the solutions proposed by the respondents are coincided with what has been already planned by the city authorities. If in the near future at least some of the planned investments are implemented it might limit transport congestion in the city as well as the inhabitants’ evaluation of the actions taken by local authorities in relation to congestion might improve.

5. DISCUSSION AND CONCLUSIONS

One of the main causes of increasing traffic congestion in Rzeszow is fast-paced growth of the area of the city (since 2006, the city has expanded its administrative boundaries six times) and moving out inhabitants from the city center into the suburbs. As the result, growing number of people who work in Rzeszow is forced to commute every day, which results in increasing traffic and leads to traffic congestion. This phenomenon has been occurring in Poland for years but if one compares Rzeszow to other Polish cities, traffic congestion caused by commuting distinguishes the capital of Podkarpackie voivodship significantly.
The fact that there are no ring roads (from the north to the south) and motorway (east-west) is also the reason why traffic congestion in Rzeszow occurs with increasing transit traffic.

If all municipal investments related to road infrastructure are implemented, the speed of vehicles driving through the city might increase substantially. There are already some noticeable improvements – according to statistics available on Korkowo.pl website in June 2012, the average speed for vehicles driving in the city significantly increased (to 33km/h from the distance up to 2 kilometers from city center and to 44 km/h at the distance of 2-5 km from the city center) [9]. Further reduction in traffic congestion will contribute in the future to development of Rzeszow and improvement of its economic attractiveness, as well as to better evaluation of effectiveness of solutions implemented by the city authorities to solve problems with road infrastructure.

LITERATURE