Collective transport as a tool to reduce congestion – case study

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Abstract. In view of the increase in population’s wealth and thus in the quality of life, the number of individual transport means is increasing significantly. Today’s society values comfort and freedom of movement, and consequently is not willing to use public transport on a mass scale, which always entails certain restrictions. However, in a situation of recurring congestion, especially in urban and industrialized areas, as well as increasing air pollution caused by emissions of harmful substances from the combustion of oil-based fuels, it is necessary to ask a question whether we should not seek solutions that would significantly reduce these phenomena. One such measure is the organization of collective transport by companies as an alternative to individual employee commuting. This paper presents the research results that show in a selected area of the Silesian agglomeration on what scale the collective transport organized by the company influences the local congestion and emission of harmful substances into the air.

1. Introduction

Currently, one of the most visible traffic problems on the roads is the constantly increasing level of transport congestion. This phenomenon affects not only large urban complexes, but is more or less present in virtually every inhabited area. Its negative effects are experienced by an increasing number of inhabitants all over the world, and the financial losses incurred are significant [1-2]. Unfortunately, very often it is very difficult and expensive for local authorities to develop comprehensive solutions and methods to fight against transport congestion, and therefore all activities starting with large production companies, which by organizing collective transport for their employees contribute significantly to reduce the congestion phenomenon, are highly important.

Transport is an energy-intensive and time-consuming process that causes high emissions to the atmosphere. Each unnecessary kilometer on transport routes brings additional economic and ecological costs, and reduces the satisfaction of transport service users. Transport must be developed in such a way that, assuming mobility increases, it would be possible to meet the society’s needs. At the same time, the transport development should be associated with the reduction of consumption of non-renewable energy resources and the reduction of pollutant emissions, which may cause irreversible changes with negative consequences for the future [2-5]. An important element
contributing to the development of modern transport, which will meet the requirements of modern society, but also of the natural environment, is seeking methods to reduce congestion. Congestion is an accumulation of vehicles which causes overloading of the network and hinders the flow of transport processes. The congestion of transport network concerns vehicle owners, passengers, drivers and transported loads [6]. It reduces mobility, which in turn is related to: increased costs of road infrastructure maintenance; increased vehicle operating costs; time losses; risk of failure to meet delivery dates; inconvenience of travel for passenger transport; increased environmental pollution due to increased air emissions; more accidents.

The occurrence of transport congestion will always lead to significant inconvenience in traffic. Although the congestion effect will always be the same, the nature of congestion may vary considerably. Two types of transport congestion are distinguished [1, 7]:

- random congestion or non-recurring congestion – caused by accidental events which are difficult or impossible to predict, e.g. bad weather conditions, accidents, events which increase traffic (e.g. protests, concerts);
- reoccurring congestion – related to excessive transport demand, significantly exceeding road capacity, occurring e.g. during peak hours.

The counteraction of congestion may take place on three levels [8]:

- expanding the infrastructure – mainly through the construction of ring roads, which enable to relieve the city centres, and the location of terminals and logistic centres in zones which do not hinder the flow of city traffic. Infrastructure development also includes the reconstruction of existing roads into collision-free.
- improving traffic organization – mainly thanks to intelligent traffic control systems and the introduction of regulations such as night-time supply of points most vulnerable to congestion.
- reducing traffic volume – mainly thanks to the expansion of collective transport systems and organization of alternative transport sources such as unmanned bicycle rental stations. In large agglomerations, the expansion of collective transport system must be based on investments in various transport branches, and the diversification of available transport means is necessary to achieve the effect.

The definition of public collective transportation included in the Act on Public Collective Transport states that it is a regular public transport of passengers carried out at certain intervals and on a specific communication line or network [9]. Thus, collective transport belongs to the group of passenger transport [10]. For the purposes of research presented in this paper, based on the definition of public transport, the collective transport has been defined as transport available to a specific group of people, carried out regularly at specific intervals. According to Jan Podoski, for a given transport system to be considered a means of collective transport, it must meet three conditions [11]:

- its vehicles must be accessible to anyone who follows the regulations in force and pays the costs or is entitled to travel free of charge,
- vehicles run according to a rigid timetable, regardless of their capacity; the timetable is known to users,
- vehicles must follow fixed routes and stop at specific stops.

Figure 1 shows the directions of modern transport implementation, where among others the dependence of collective transport on reducing congestion is indicated.
The analysis of Figure 1 clearly shows that collective transport has an impact on the congestion reduction, which increases the mobility of people and reduces the consumption of raw materials, which is important for the development of modern civilization.

2. Description of research methods

The aim of this study was to show the validity of maintaining public transport – company transport for employees of NGK Ceramics Polska Sp. z o.o. located in the economic zone in Gliwice. The main motive of employers organizing employee commuting was to meet the expectations of employees who directly experienced the congestion through the inconvenience related to extended travel time to work, caused by the high intensity of traffic during rush hours.

Research was conducted on the basis of analysis of employee transport organized by NGK Ceramics Polska Sp. z o.o. This transport is carried out on 5 transport routes in two-shift mode in directions: Zabrze, Ruda Śląska, Knurów, Piekary Śląskie. The routes are handled by transport means of the size corresponding to the employees’ needs, which currently makes up a fleet of 22 to 55 seats in one bus. Each of the transport means has a designated route with a list of stops, and any modifications due to road repairs or other traffic obstructions are passed on to employees. The design of routes was preceded by thorough studies in order to determine the optimal distribution of transport means. The occupancy rate of seats available on the buses at a level of about 80% indicates a good adaptation of the size of transport means to the demand for travel, and any fluctuations in the number of passengers are caused by uneven demand for individual employee brigades.

The research method used in this study was direct observation of employee transport and direct interview with employees using collective transport. The observations were conducted in March and April 2019. The number of observations was 10. This observation included such elements as the number of passengers on particular transport routes on a given day. The dates of observations were random. All data obtained from the studies are estimates.

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The study was carried out in the following way:
- direct interview with employees using public transport,
- observation of the number of passengers on individual collective transport routes,
conducting calculations necessary to prove the validity or not of the further implementation of collective – company transport.

3. Results of conducted research

On the basis of observations, it was established that the demand of employees for commuting according to established routes amounted to 183 persons per each working shift, respectively. Table 1 presents the results of conducted observations.

| Travel route | Number of passengers in individual observations [pcs] | Average |
|--------------|------------------------------------------------------|---------|
| Bus 1 Zabrze | 48 40 51 46 50 43 37 50 44 43 45 |         |
| Bus 2 Zabrze | 39 27 40 40 35 29 35 33 39 38 36 |         |
| Bus 3 Ruda Śląska | 46 42 58 44 42 54 47 37 51 48 47 |         |
| Bus 4 Knurów | 33 39 38 38 41 36 29 34 27 39 35 |         |
| Bus 5 Piekary Śląskie | 23 19 26 26 11 24 21 22 10 22 20 |         |

Based on the data from Table 1, calculations were conducted in order to determine the data needed to determine the estimated number of collective transport passengers on a monthly basis. The results were presented in Table 2.

| Route | Length (back and forth) [km] | Distance travelled on a monthly basis [km] |
|-------|------------------------------|------------------------------------------|
| Bus no. 1 | 45 | 2 | 90 | 2745 | 38 | 1159 |
| Bus no. 2 | 36 | 2 | 72 | 2196 | 38 | 1159 |
| Bus no. 3 | 47 | 2 | 94 | 2867 | 102 | 3111 |
| Bus no. 4 | 35 | 2 | 70 | 2135 | 56 | 1708 |
| Bus no. 5 | 20 | 2 | 40 | 1220 | 82 | 2501 |
| Total | 183 | 326 | 9943 | 9638 |

The following calculations have been carried out to estimate the data included in Table 2:

- number of working shifts (continuous operation – 7 days a week after 2 12 h shifts),
- number of passengers per day as a product of the average number of passengers and the number of working shifts,
- number of passengers per month as the number of passengers per day multiplied by 30.5 days,
- route length based on data obtained from NGK Ceramics Polska,
- number of kilometers covered on a monthly basis as the length of route multiplied by 30.5 days.

In order to be able to establish the validity of collective transport by NGK Ceramics Polska, a simulation study was carried out regarding the situation if employees had to use individual transport. In a face-to-face interview they were asked about such data as the average number of passengers in car, distance that would have to be covered in order to reach and from the workplace to their home.
From the data obtained in this interview, the average number of people in car commuting to and from work was determined at 1.7 passengers. The average distance that employees would have to travel to and from work to home was also calculated at 40 km. Based on this data, an estimate was made of the number of passenger cars that would have to go on the road and the number of kilometers that employees would have to travel in order to commute to and from work in individual transport. These data were presented in Table 3.

Table 3. Commuting by individual transport in the lack of collective transport.

| Average number of passengers in 1 car according to intelligence data | Number of travelers per month [pcs] | Number of transports by car | Average daily distance covered by 1 employee according to interview data [km] | Number of kilometers travelled by passenger cars on a monthly basis [km] |
|---|---|---|---|---|
| 1.7 | 9943 | 5849 | 40 | 233953 |

The following calculations have been carried out to estimate the data included in Table 3:
- number of travelers per month – carried over as the same number that travels by company transport (Table 2),
- number of car transports by number of travelers divided by the average number of passengers in 1 car,
- number of kilometers travelled by passenger cars on a monthly basis – expressed as the product of the number of transports by private cars and the average distance.

Based on data on the number of kilometers covered by collective transport (Table 2) and individual transport (Table 3) during one month, an estimate of the fuel consumption of both groups was calculated. Results were presented in Table 4.

Table 4. Estimated fuel consumption for collective and individual transport.

| Fuel consumption in [l/100 km] | Number of kilometers travelled per month [km] | Estimated fuel consumption [l] |
|---|---|---|
| Bus no. 1 | 30 | 1159 | 347.7 |
| Bus no. 2 | 30 | 1159 | 347.7 |
| Bus no. 3 | 30 | 3111 | 933.3 |
| Bus no. 4 | 30 | 1708 | 512.4 |
| Bus no. 5 | 15 | 2501 | 375.15 |
| Total | 135 | 9638 | 2516.25 |
| Private cars | 8 | 233953 | 18716 |

The following assumptions have been made to calculate the data included in Table 4:
- fuel consumption in [l/100 km] – 30 l for buses with over 40 seats, 15 l for minibuses with 24 seats and 8 l for passenger cars were assumed,
- estimated fuel consumption as a product of the number of kilometers and the estimated combustion level.

Difference in fuel consumption for the same number of passengers travelling by private and collective transport was presented in Figure 2.

The analysis of Figure 2 shows clearly that fuel savings are achieved by replacing individual transport with collective transport.
The second aspect identified in this study is a difference in road load (with particular emphasis on economic zone areas). The number of transport means for individual and collective transport was shown in Figure 3.

The following calculations were conducted for the data presented in Figure 3:

- In order to calculate the quantity of transport means for collective transport, it was assumed: 5 routes, which are handled by 5 buses. Each of them perform their services 4 times a day (2 shifts per day). The number of working days per month is 30.5 days. Therefore, the number of public transport vehicles is the product of daily routes and the number of working days per month, which is 610.
- The quantity for individual transport was taken from Table 3.

Figure 3 shows that the choice of collective transport reduces the road load by 5,239 cars per month, which gives 172 cars less daily on the access roads to NGK Ceramics Polska Sp. z o.o. Taking this into account, it can be clearly stated that the reduction of load, which is irregular (breakthrough of changes), is so important that it can be considered as a real congestion counteraction.

4. Results of conducted research

The research results presented in this paper confirm the validity of organizing collective transport by NGK Ceramics Polska Sp. z o.o., as it significantly contributes to the reduction of congestion by eliminating 172 passenger cars daily during peak hours from local roads. However, the effectiveness of collective transport impact on the congestion would be greater if it was introduced systematically (common network of employee commuting for several companies) and with the support of local authorities. However, employee commuting initiatives are not of interest to urban units, although they reduce urban congestion. Currently, also the activities of entrepreneurs are directed mainly towards their own business, and to provide their employees with appropriate working conditions, and the positive impact on the surroundings is in a way an additional effect, which is not the primary goal of enterprises.

Transport congestion is an undeniably negative phenomenon, affecting practically every aspect of modern human life. Its impact on the environment cannot be overlooked either. However, it is not a new phenomenon, but it has accompanied our civilization since the beginning of its existence. Continuous development and the associated increased need for mobility further intensifies it. The limitation of this problem or even its complete elimination is currently one of the most important and most difficult tasks facing the society [3]. Therefore, the activities of companies organizing collective transport are an extremely valuable initiative and should be supported by local authorities.

5. Conclusions

On the basis of conducted research, it can be concluded that local initiatives of entrepreneurs to organize collective transport for their employees have a real impact on the environment and contribute to the quality of life of the inhabitants.
Collective transport has a very high impact on reducing congestion and its use is justified in terms of public interest and environmental effects, as confirmed by the studies presented. Companies should be supported in maintaining and expanding their collective transport. It is also necessary to raise the awareness of both entrepreneurs and employees that the use of such transport has a direct impact on improving the quality of life and protecting the environment, which in the modern world is an extremely important issue that affects the lives of modern and future generations.

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