

Assessment of Citizens' and Employees' Mobility by Public Transport

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Abstract. The contribution analyzes the level of service by bus and rail transport in the Přerov area. Exploration is carried out through key indicators such as transport speed and number of connections. Based on these indicators, the public transport service is assessed between the statutory city of Přerov and the towns of Hranice, Kojetín, Lipník nad Bečvou, Potštát and Tovačov. Thereafter, there are proposed measures to increase the mobility of citizens and employees by public transport.

1 Introduction

Mobility is one of the basic needs of the population. The increasing need for relocation of citizens brings an increase in individual car traffic, to which must be offered an adequate alternative to public transport. To ensure successful public service provision, it must be adapted to the individual requirements of citizens who need to be transported to schools and school facilities, to public authorities, to employment, to healthcare facilities, and to satisfy cultural, recreational and social needs. The most significant group of passengers, however, represents the number of people transported outside of the morning transport peak 5:00 - 8:00 and the afternoon transport peak from 13:00 - 17:00 on working days, mainly those who are working in three-shift operation. Therefore, it is necessary to deal with public transport both throughout the day but also before and at the end of each shift [1, 2].

2 Solution process

In order to assess the service of the territory by public transport it is necessary to look at it from a passenger's point of view, which requires time availability of the area by the given speed of connection in a given period of time and sufficient number of connections to be carried out during the given period of time [3,4].

In terms of quantity, the problem of the service of the territory provided by public transport can be expressed by the speed of the connection, which is expressed by means of distance and travel time, the number of connections per hour, which is expressed

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by the number of connections during the reference period and the indicator of the public transport operator including the speeds of the connections and the number of connections. The procedure used was proposed by Pova [5, 6].

Indicator of the speed of connection:

$$v_{ij} = \frac{d_{ij}}{t_{ij}} \cdot 60 \text{ [km/h]} \quad (1)$$

where:

d_{ij} - the length of junction between the i -th place and j -th place [km],

t_{ij} - the time of travel between the i -th place and j -th place [h].

Indicator of the number of connections per hour:

$$n_{ij} = \frac{N_{ij}}{T_{ij}} \text{ [h}^{-1}\text{]} \quad (2)$$

where:

N_{ij} - the number of connections between i -th place and j -th place in the monitored time period [-],

T_{ij} - the time period in which the number of connections between the i -th place and j -th place is monitored [h].

Indicator of the service area:

$$o_{ij} = \frac{d_{ij} \cdot 60 \cdot N_{ij}}{t_{ij} \cdot T_{ij}} \text{ [km/h}^2\text{]} \quad (3)$$

where:

d_{ij} - the length of junction between the i -th place and j -th place [km],

N_{ij} - the number of connections between i -th place and j -th place in the monitored time period [-],

t_{ij} - the time of travel between the i -th place and j -th place [h],

T_{ij} - the time period in which the number of connections between the i -th place and j -th place is monitored [h].

3 Assessment of the mobility of citizens and employees

The application part will be focused on public transport service in the Přerov district, which is a major economic and industrial area. This is the assessment of the mobility of citizens between Hranice, Kojetín, Lipník nad Bečvou, Potštát and Tovačov, which consists of towns in the Přerov district and the statutory town of Přerov. The assessment of citizens' mobility will then be extended to assess the mobility of employees in the three-shift operation. Therefore, increased attention needs to be paid to this issue.



Fig. 1. Map with cities in the district Přerov. Source: [7]

3.1 Assessment of the mobility of citizens

The mobility of citizens in the Přerov region was examined on a working day during the period 4:00 - 24:00, when the active life of the inhabitants takes place. The input data for the mobility of citizens in the period 4:00-24:00 are listed in Table 1.

Table 1. The input data for the assessment of the mobility of citizens. Source: [8]

Session	Bus transportation			Rail transportation		
	Length of junction [km]	Time of travel [min]	Number of connections [-]	Length of junction [km]	Time of travel [min]	Number of connections [-]
Hranice - Přerov	31	55	6/6	29	20	41/42
Kojetín - Přerov	28	33	6/6	17	18	31/31
Lipník n. B. - Přerov	17	30	15/16	15	12	18/17
Potštát - Přerov	-	-	0/0	-	-	0/0
Tovačov - Přerov	13	21	22/23	-	-	0/0

On the basis of information on connections in the assessed sessions, the research was carried out using indicators of the speed of connections, the number of connections, the operation of the territory, which are clearly presented for bus and train transport in Table 2.

Table 2. Indicators for the assessment of the citizens' mobility. Source: authors

Session	Bus transportation			Rail transportation		
	Speed of connection [km/h]	Number of connections [h ⁻¹]	Operation area [km/h ²]	Speed of connection [km/h]	Number of connections [h ⁻¹]	Operation area [km/h ²]
Hranice - Přerov	34	0,3/0,3	10/10	87	2/1	174/87
Kojetín - Přerov	51	0,3/0,3	15/15	57	1,6/1,6	91/91
Lipník n. B. - Přerov	34	0,7/0,8	24/27	75	0,9/0,8	68/60
Potštát - Přerov	0	0/0	0/0	0	0/0	0/0
Tovačov - Přerov	37	1,1/1,2	41/44	0	0/0	0/0

Table 2 shows that, with the exception of transport in the Potštát - Přerov session, there is a good offer of train transport connections, supplemented by bus transport in the Hranice - Přerov, Kojetín - Přerov, Lipník n. B. - Přerov routes, which confirm the higher values of the territory and a bus service in the Tovačov - Přerov session.

3.2 Assessment of the mobility of employees

The mobility of employees in the Přerov region was gradually examined on a working day in the hours of 4:00 - 6:00 and 14:00 - 16:00, 12:00 - 14:00 and 22:00 - 24:00, 20:00 - 22:00 and 6:00 - 8:00 in which the transfer of employees to the three-shift operation takes place. The input data for examining the mobility of employees during the periods mentioned are shown in Table 3.

Table 3. The input data for the assessment of the mobility of employees. Source: [8]

Session	Bus transportation			Rail transportation		
	Length of junction [km]	Time of travel [min]	Number of connections [-]	Length of junction [km]	Time of travel [min]	Number of connections [-]
Hranice - Přerov	31	55	1/1	29	20	4/4
Kojetín - Přerov	28	33	1/1	17	18	1/3
Lipník n. B. - Přerov	17	30	2/3	15	12	2/2
Potštát - Přerov	-	-	0/0	-	-	0/0
Tovačov - Přerov	13	21	2/4	-	-	0/0
Hranice - Přerov	31	55	1/0	29	20	3/2
Kojetín - Přerov	28	33	1/1	17	18	3/1
Lipník n. B. - Přerov	17	30	2/2	15	12	1/1
Potštát - Přerov	-	-	0/0	-	-	0/0
Tovačov - Přerov	13	21	4/1	-	-	0/0
Hranice - Přerov	31	55	0/2	29	20	3/4
Kojetín - Přerov	28	33	1/1	17	18	2/3
Lipník n. B. - Přerov	17	30	2/2	15	12	1/3
Potštát - Přerov	-	-	0/0	-	-	0/0
Tovačov - Přerov	13	21	2/2	-	-	0/0

On the basis of information on connections in assessed sessions, the survey was carried out using indicators of the speed of connections, the number of connections and the operation of the area, which are clearly presented for bus and train transport in Table 4.

Table 4. Indicators for the assessment of the employees' mobility. Source: authors

Session	Bus transportation			Rail transportation		
	Speed of connection [km/h]	Number of connections [h ⁻¹]	Operation area [km/h ²]	Speed of connection [km/h]	Number of connections [h ⁻¹]	Operation area [km/h ²]
Hranice - Přerov	34	0.5/0.5	17/17	87	2/2	174/174
Kojetín - Přerov	51	0.5/0.5	26/26	57	0.5/1.5	29/85
Lipník n. B. - Přerov	34	1/1.5	34/51	75	1/1	75/75
Potštát - Přerov	0	0/0	0/0	0	0/0	0/0
Tovačov - Přerov	37	1/2	37/74	0	0/0	0/0
Hranice - Přerov	34	0.5/0	17/0	87	1.5/1	131/87
Kojetín - Přerov	51	0.5/0.5	26/26	57	1.5/0.5	86/29
Lipník n. B. - Přerov	34	1/1	34/34	75	0.5/0.5	38/38
Potštát - Přerov	0	0/0	0/0	0	0/0	0/0
Tovačov - Přerov	37	2/0.5	74/19	0	0/0	0/0
Hranice - Přerov	34	0/1	0/34	87	1.5/2	131/174
Kojetín - Přerov	51	0.5/0.5	26/26	57	1/1.5	57/85
Lipník n. B. - Přerov	34	1/1	34/34	75	0.5/1.5	38/113
Potštát - Přerov	0	0/0	0/0	0	0/0	0/0
Tovačov - Přerov	37	1/1	37/37	0	0/0	0/0

Table 4 shows that except the Hranice - Přerov session, there is a decrease in the quality of the connection offer in some periods. These are mainly train connections in the Kojetín - Přerov session for the morning shift, the afternoon shift and the night shift see the low values of the operator indicator of areas 29, 29 and 57 and in the Lipník n. B. - Přerov session for afternoon shift and afternoon shift, see the low values of the 38/38 operator indicator and the bus transport connections in the Tovačov - Přerov session for the morning shift, afternoon shift, night shift and night shift, see low values of the 37, 19, 37/37 traffic indicator.

4 Evaluation

All cities, except the city of Potštát, located on the northern outskirts of Přerov, have a public transport connection with the statutory city of Přerov (Table 5 and 6).

Public transport, which provides mobility for citizens and employees, shows a higher level of service to the area by train transport and a lower level of service to the area by bus transport, due to more favorable conditions on railway lines in the case of train transport and less suitable conditions on roads in the case of bus transport (Table 5 and 6).

An analysis based on the comparison of citizens' mobility throughout the day and the mobility of employees at partial intervals revealed that there were significant differences between the values of quality indicators of public transport (Table 5 and Table 6).

Table 5. Evaluation of bus transport in Přerov district. Source: authors

Session	Operation area 4:00-24:00 [km/h ²]	Operation area 04:00-06:00/14:00-16:00, 12:00-14:00/22:00-24:00, 20:00-22:00/06:00-08:00 [km/h ²]		
Hranice - Přerov	10/10	17/17	17/0	0/34
Kojetín - Přerov	15/15	26/26	26/26	26/26
Lipník n. B. - Přerov	24/27	34/51	34/34	34/34
Potštát - Přerov	0/0	0/0	0/0	0/0
Tovačov - Přerov	41/44	37/74	74/19	37/37

Table 6. Evaluation of the rail transport in Přerov district. Source: authors

Session	Operation area 4:00-24:00 [km/h ²]	Operation area 04:00-06:00/14:00-16:00, 12:00-14:00/22:00-24:00, 20:00-22:00/06:00-08:00 [km/h ²]		
Hranice - Přerov	174/87	174/174	131/87	131/174
Kojetín - Přerov	91/91	29/85	86/29	57/85
Lipník n. B. - Přerov	68/60	75/75	38/38	38/113
Potštát - Přerov	0/0	0/0	0/0	0/0
Tovačov - Přerov	0/0	0/0	0/0	0/0

5 Conclusion

During providing of the public transport from cities to statutory cities, it is necessary to take into account their location within the district, as the cities that are located in the peripheral parts of the district do not have to move the traffic streams to the statutory city but may go beyond the neighboring district.

To ensure high-quality mobility for citizens and public transport employees, it is necessary to deal with train and bus services separately, including the possibility of combining them, and by improving the supply and speed of bus transport connections.

In addition to ensuring high-quality mobility for both citizens and bus and train staff, qualitative indicators must be ensured both throughout the day and at partial intervals in which workers are transported in three-shift traffic.

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