

Modal split analysis through the traffic volumes

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Abstract. The article deals with the analysis of the modal split in Žilina self-region (ŽSK) during the morning and afternoon peak hours. The results are based on a mobility survey in the region. Households and inhabitants were divided into three main groups of the population. The first group characterized the inhabitants in the district towns, the second group in the other towns and the third covered the villages. The modal split was analyzed for all main groups and the most numerous subgroup - economically active people. In parallel with the analysis of mobility data, we analyzed data from the traffic surveys on several congested profiles. From the results, we determined the amount of traffic above the real road capacity limit. In the last part of the article, we present an example of combining data from the mobility and transport surveys. We defined the number of trips that need to be transferred to another transport system - the train.

1. Introduction

The mobility is generally defined as the ability to move or be moved freely and easily. The mobility (meaning as the number of trips per time unit) and travel time can be described as basic quantities of mobility. Their values represent the basic tool for SUMP (Sustainable Urban Mobility Plan) of functional urban areas (FUA). The data is preceded by several surveys, studies, and analyzes, which are usually imported into the transport model. In this article, we deal with the analysis of data from mobility surveys and traffic volumes surveys. The surveys were processed as a part of the input data for ŽSK. In principle, data from a mobility survey are mainly used to set up a demand model. The results are matrices of transport relations. The matrices show the number of trips between two points for a selected time interval. Theoretically, such data is calculated for the given time intervals to describe all the characteristics of the passenger load. But practically, it depends on the existing models for traffic [1]. The volumes survey data are used in the model calibration process. The article aims to demonstrate the possibility of linking data from both surveys. We focused on road profiles with the regularly exceeded saturation and with high concentrations of particulate matter (PM) [2]. These profiles are usually unsatisfactory also from measuring surface evenness [3]. The base-saturation flow rate value in HCM is derived from field data collected in developed countries. The adopted value in Slovakia is 1800 passenger car/h/lane. [4] We can determine the real capacity of roads from the measured data. Subsequently, we focused on expressing the number of vehicles above the capacity limit. The above volume limit was taken over into the demand model, which was set according to the data from the mobility survey. By changing the input quantities, such as e.g. fare, we can determine the necessary factors to change modal split for specific demand strata.

2. Mobility survey in Žilina self-governing region

Mobility survey (travel survey) includes information about the characteristics and determinants of travel activities such as trip purpose, start and end time, duration, cost, transport modes, location of origin, and destination [5].

The database for mobility characteristics is based on a mobility survey in Žilina region. The survey was made in 2016. The Zilina self-region with the area of 6,801 km² [6] lies on the north-western and northern part of Slovakia, it has borders with the Czech Republic and with Poland.

The actual data from the Slovak Statistical Office was used for specifying the credible sample. The survey was then performed in every village where the required number of households is greater than 10. Finally was asked 6,231 households with 18,382 inhabitants. The survey was conducted through questionnaires. The questions were formulated to describe the daily activity, transport habits, and trip purpose. Every interviewee was assigned to a predetermined population group.

The database contains 33,688 trip descriptions. Almost 50% of them contain the activity “JOB”(attraction or production). The economically active people share almost 67% of total inhabitants. The transport mode “car driver” was selected for 42% of work trips.

2.1. Peak time modal split

The congested roads reach the limit traffic volumes in the morning and afternoon peak hours. The main task of the article is to link traffic volumes data with mobility survey data. The evaluation of the modal split was analyzed for the morning time period (05:00 – 09:00) and for an afternoon time period (13:00 – 17:00).

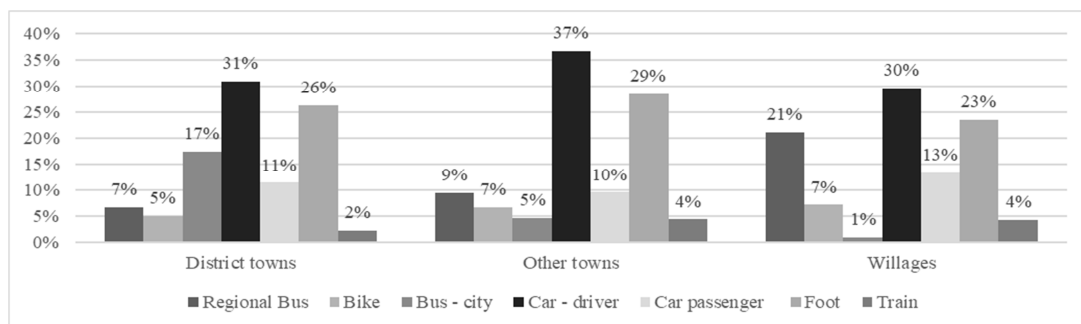


Figure 1. The morning modal split in district cities, other cities, and villages during the morning peak hours.

The equilibrium between the use of transport modes is the key to sustainable transport. The demand strata "economically active people - trips to the job" was selected to the next part of the analysis.

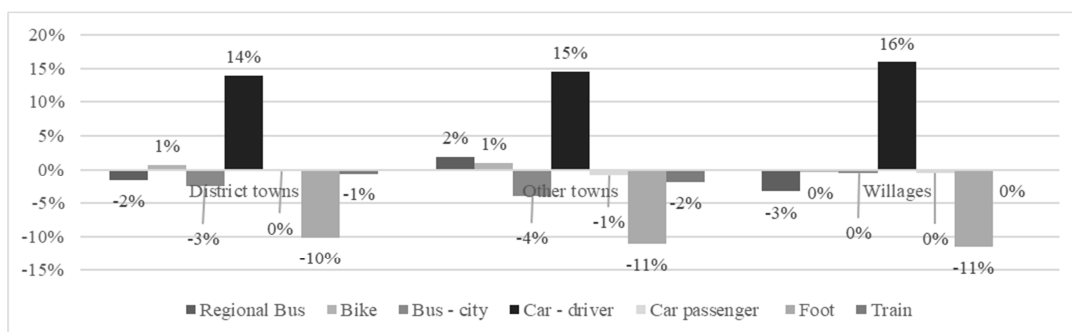


Figure 2. The modal split differences between total trip and demand strata “economically active people - trips to the job during morning peak”.

The character of daily traffic is different depending on the distance from traffic-attractive zones. We divided the database set of morning and afternoon trips by location into three subcategories: district city, other city, villages. We decided to analyze morning peak hours because the traffic load is more concentrated. The largest share (more than 30%) in the modal split is represented by trips marked as "car driver". The transport mode "Car passenger" is highest in villages. The results are presented in figure 1.

A transport mode "car driver" creates a significant proportion in modal split (figure 2). Approximately 45% of trips to work are realized by "car - driver" mode. The share of this mode is 15% higher compared to the modal split for all trips. The data from traffic count are analyzed in the next section.

3. Traffic survey

Profile surveys were carried out in the Žilina Region in September and October 2018, on roads I, II, and III. classes in selected fifty-two profiles (a total of 104 traffic flows). Data from individual measurements were recorded for seven consecutive days from 00:00:00 to 23:59:59. For a better idea, in figure 3 the locations where the profile measurements were performed are marked.

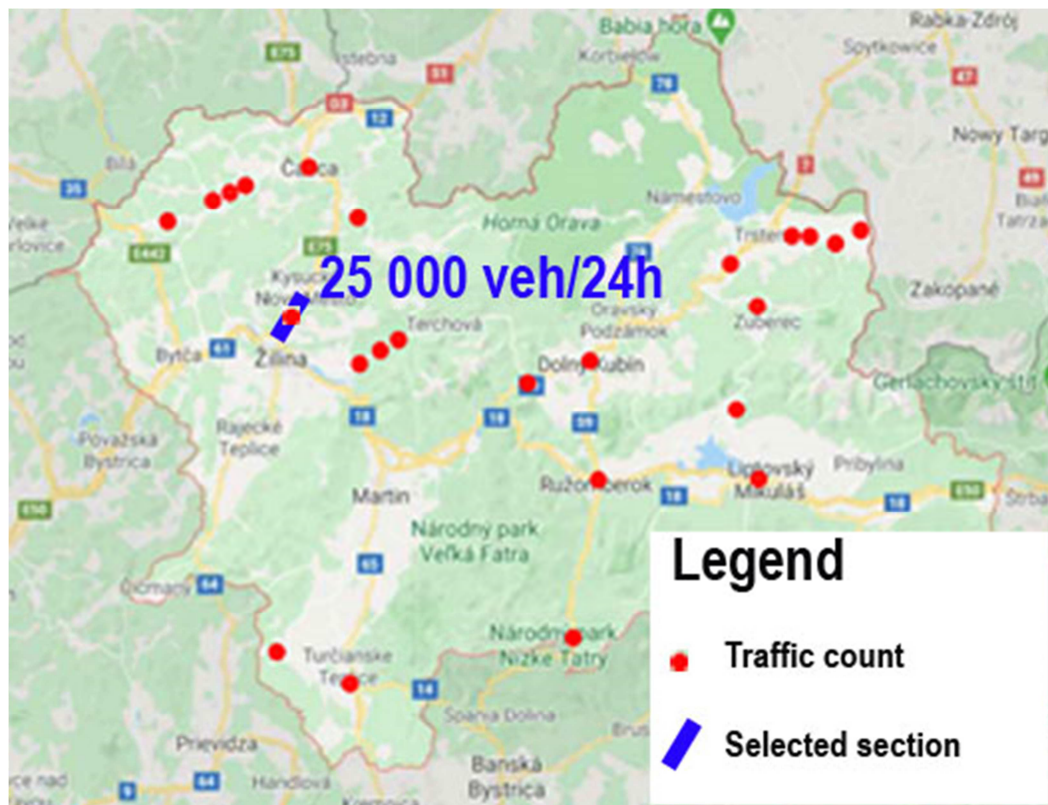


Figure 3. Traffic counts locality (red), application of results section (blue).

Gathered data was analyzed in Matlab. The example of the evaluated parameters of the overcapacity assignment traffic flow at road I/11 (figure 4).

The first graph (1-1) presents the relationship between speed and traffic volumes. The second (1-2) presents the relationship between traffic density and traffic volumes. These two data set were used for evaluation of the real capacity. The maximum value of the traffic volumes per hour was nearly 1800 veh/h. The third graph (2-1) complements the ratio between speed and density. The value of density increases as the speed decreases. The last graph presents the interrelation of traffic volumes, speed, and density.

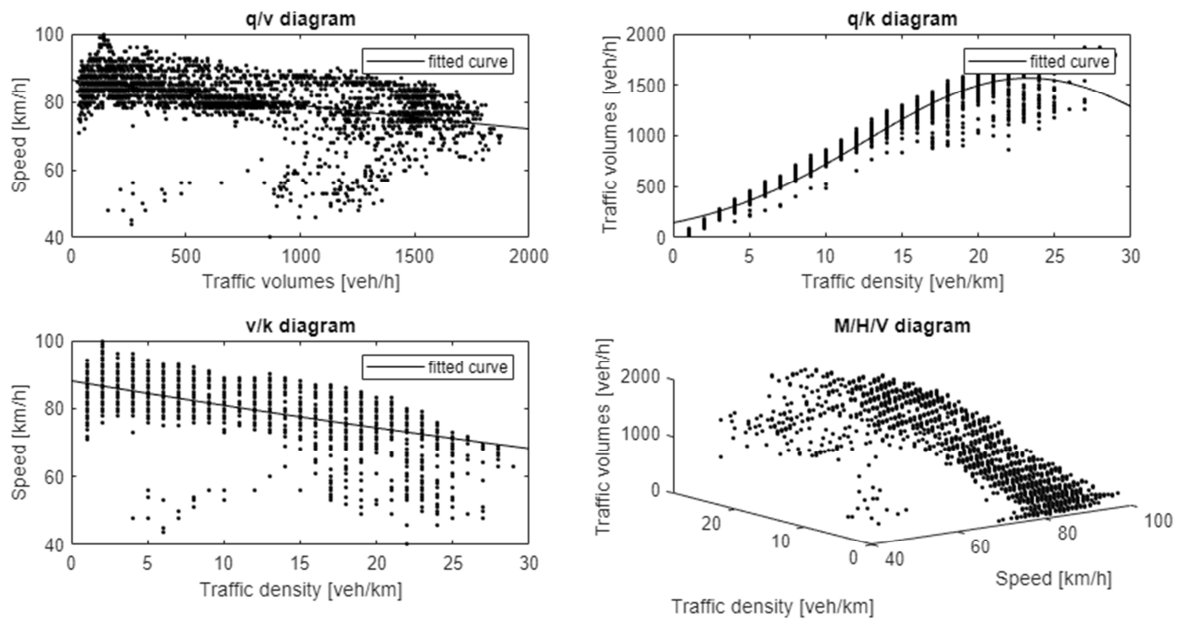


Figure 4. Traffic flow evaluation (traffic volumes, density, and speed).

3.1. Determination of the load capacity

The efficiency of the traffic system depends on the capacity of the traffic infrastructure. This capacity is defined as the “largest volume of traffic that traffic flow can reach at a given distance and traffic conditions at the cross-section determined for this flow” [7]. The capacity is determined by the density of the platoon of vehicles and the speed with which the platoon passes through the cross-section.[8]

The real capacity was determined as the maximum of fitted function (figure5) between density and traffic volumes.

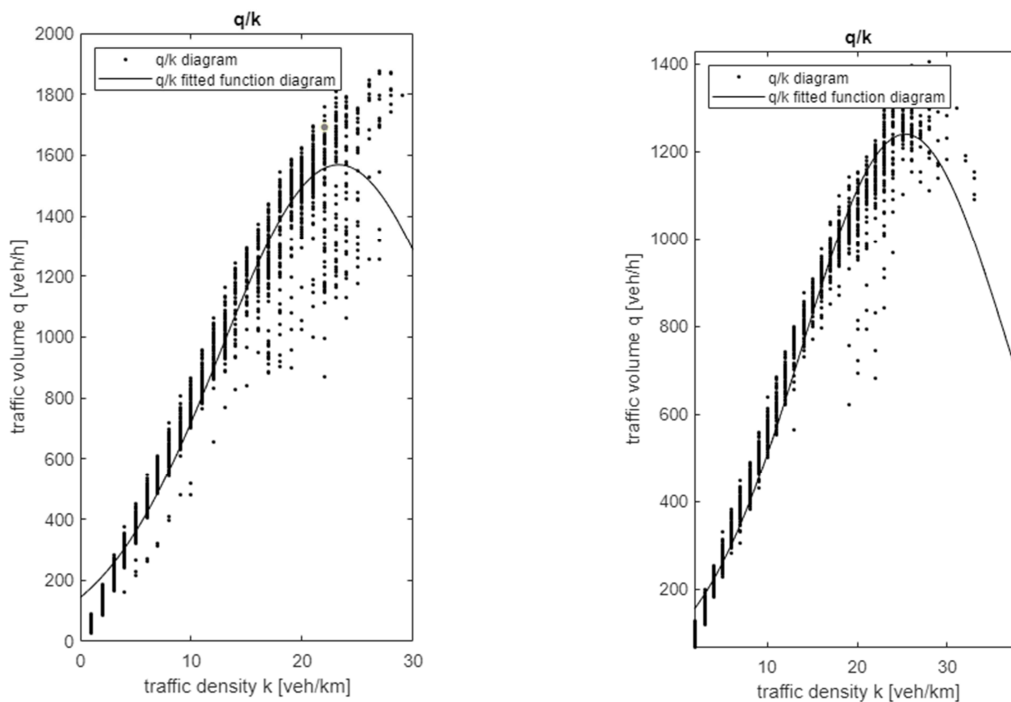


Figure 5. The compare of traffic volume/density ratio between two traffic flow.

Figure 5 presents the optimum capacities for two opposite lanes (two traffic flows). The optimum value was estimated by plotting the flow-efficiency diagram and finding the extremum point [9]. In this case, efficiency and related parameters should be estimated for various values of flow. The extremely fitted function was 1568 veh/h and 1293 veh/h. The results couldn't be used for generalization of exact road capacity. The hourly traffic volumes were calculated as the sum of the four 15 min traffic volumes. The exact values should be evaluated for shorter intervals. Brilon and Zurlinden (2003) introduced 5 to 15 min intervals as the best time intervals after investigating different values [10].

Our study collects the traffic count data at a specific place with data from a mobility survey between traffic-relevant areas.

4. Application of the survey results

We used data from both surveys to specific transport “funnel”, which opens into congested place on the road I/11 in Slovakia. The maximum value of exceeding capacity was 350 veh/h from all measured days. The average maximum of exceedance was 202 veh/h.

We focused to import the value of overcapacity volumes to the demand model. Passenger transport demand is a function that covered the amount and type of transport that people will choose for specific factors (distance, price, and other quality conditions). Four-Step travel demand modelling is the traditional procedure utilized for transportation forecasts. It contains several submodels (trip generation, trip distribution, mode choice, and trip assignment). The mode choice model (modal split) is based on the utility function theory. Mode choice models determined the traveller's choice of which mode of transport to take, eg car, public transport, or whatever. The Utility functions are defined for each demand strata (stratum).

The sample for the database trips file was extracted from the mobility survey of Žilina Region. The factors (B) were calculated by software Biogeme which has been developed by Michel Bierlaire, Ecole Polytechnique Fédérale de Lausanne, Switzerland [10]. Biogeme is an open-source freeware designed for the maximum likelihood estimation of parametric models in general, with a special emphasis on discrete choice models. [11]

The comparison of current and proposal is presented in figure 6. The modal split was changed in favour of non-collapsing road transport when the saturation of traffic flow is under 1,0. We have reached the goal of reducing the number of trips by car by almost 7%. The region transport study evaluated sufficient capacity for train transport. The best assumption for reach the new modal split was reducing train travel costs to zero. This assumption changed the ratio of other modes. The total increase in train passengers was 14%.

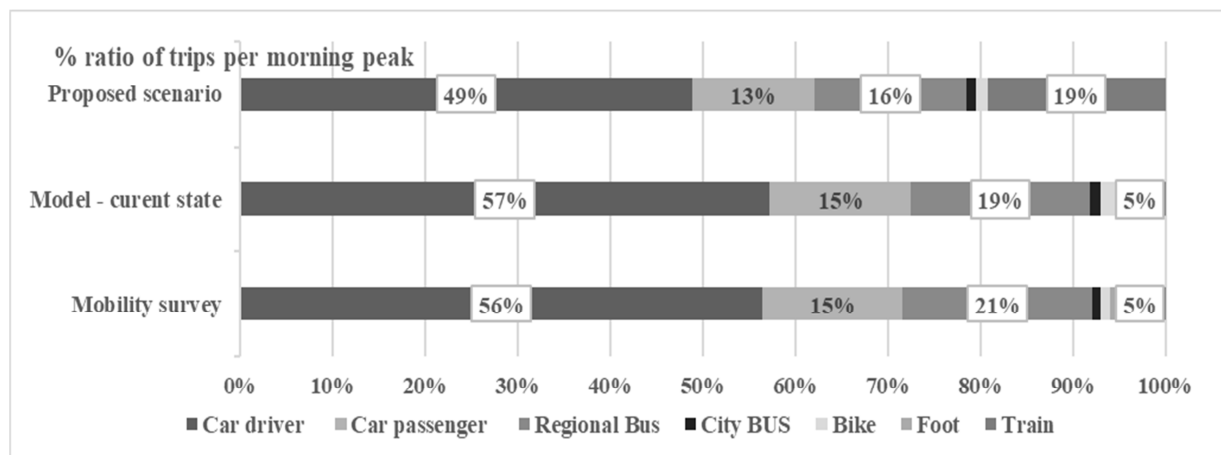


Figure 6. The compare of total modal split.

5. Conclusions

Travel time, travel cost mainly affect the choice of destination, route decision, and the choice of transport mode. We looked for opportunities for equilibrium between supply and demand for transport systems in the article. The purpose of the presented analysis was only regular trips. The most numerous trips are trips to work during the morning peak. The real route capacity was determined by density and speed. Data were gathered during 4 weeks at the regularly congested point.

The maximum value of exceeding the intensity was 350 veh/h from all measured days. The average maximum of exceedance was 202 veh/h. The utility theory was used to determine the changes in travel costs to achieve a capacity equilibrium. We analyzed scenarios with 100% subsidized train transport. The total increase in train passengers was 14%. In the next part, we want to evaluate the impact of traffic volumes on the environment by modal split changing [12, 13].

Acknowledgments

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