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LOW VEHICLE OCCUPANCY RATES AS A BIG CHALLENGE FOR URBAN MOBILITY OR HOW TO CHANGE BAD HABITS

Keywords

Average vehicle occupancy
Traffic congestion
Single occupancy vehicle (SOV)
Urban mobility

Abstract

The problem of traffic congestion in modern cities is the result of numerous factors that must be addressed by various management, regulatory and design solutions. The average vehicle occupancy, especially passenger cars, is certainly one of the significant indicators of the street network condition. In general, with the increase of the motorization rate, there is a noticeable decrease in vehicle occupancy, which directly affects the level of service. This does not conform with the green agenda of the development of sustainable and resilient cities. As part of this paper, the methodology and the results of the latest vehicle occupancy survey on selected characteristic corridors of the city of Belgrade will be presented. The research showed that passenger cars occupancy is very low, and on average is equal to 1.47 persons/car. A more detailed analysis and discussion of spatio-temporal variabilities will be presented in a separate chapter of this paper. In the concluding part, the authors will provide preliminary guidelines and suggestions for potential solutions to overcome or at least mitigate the consequences caused by the low occupancy of passenger cars in correlation with their high presence on the street scene.

1. INTRODUCTION

The problem of low vehicle occupancy (LVO) is a pressing issue that contributes to traffic congestion in cities, ultimately affecting the quality of life for all residents. There are several factors that contribute to this problem, including the increasing number of vehicles on the road, limited road infrastructure, inadequate public transport services, and poor management of the city's transportation system. Sustainable urban mobility is an essential concept for creating livable cities, but the current state of LVO contradicts this idea. Passenger cars, being the most common category of vehicles, play a significant role in the transportation system. However, as the motorization rate continues to rise, there has been a noticeable decline in vehicle occupancy, which directly impacts the overall level of service of the transportation network.

For example, the average occupancy of passenger cars in the United States decreased from 1.87 persons per vehicle in 1977 [1] to 1.50 persons per vehicle in 2019 [2]. On the other hand, the motorization rate in the United States for the last 30 years was increased by 146% [3]. This trend is not limited to the United States but is observed worldwide, indicating significant problems regarding traffic congestion. Results of the survey conducted by Fiorelo et al. [4] suggest that the typical occupancy rate in European countries is 1.7 persons per car, although this varies across countries. In Denmark, the minimum occupancy rate is 1.4 persons per car, while in Romania, it reaches a maximum of 2.7 persons per car [4]. Based on the previous, countries with a high occupancy rate tend to have low availability of cars per person. This indicates that cars are predominantly viewed as a personal mode of transportation, and carpooling appears to be driven more by necessity rather than a deliberate choice. Apart from being a fundamental issue leading to traffic congestion, LVO gives rise to various additional challenges, like heightened emissions of exhaust gases, detrimental effects on the environment, increased costs for society, overcrowding of existing parking spaces, and more [5].

In response to these challenges, the authors of this paper have conducted a comprehensive research along selected corridors in the city of Belgrade. The objective of this research is to present and discuss the methodology and the results obtained from this study. By understanding the current situation in Belgrade, valuable insights can be gained into the broader issue of low vehicle occupancy and its impact on traffic congestion. In the concluding part, the paper will provide preliminary guidelines and suggestions for potential solutions to overcome or at least mitigate the consequences caused by the low occupancy of passenger cars in correlation with their high presence on the street scene.

2. METHODOLOGY OF THE RESEARCH

The research conducted within this paper is based on recording the traffic flow (traffic counting) and recording the occupancy of vehicles at specific locations in the city of Belgrade. The methodological framework foresees four stages.

The first, **preparatory phase**, defined the basic objectives of the research, and accordingly the method of its implementation. Within this phase, characteristic locations and time periods in which it was necessary to conduct research were selected. The survey was conducted on 15 locations (main traffic corridors) in the city of Belgrade from 6am to 10pm on representative weekdays (Tuesday, Wednesday and Thursday). Locations of the conducted research are shown in the next Table and Figure.

Table 1. Research locations

Location code	Location name	Research date
TCNS 1	Pančevo bridge	Wednesday, November 2nd, 2022
TCNS 2	Branko's bridge	Wednesday, November 2nd, 2022
TCNS 3	Old Sava bridge	Thursday, November 3rd, 2022
TCNS 4	Gazela bridge	Wednesday, November 2nd, 2022
TCNS 5	Ada bridge	Wednesday, November 2nd, 2022
TCEW 1	Shopping center "Zmaj"	Thursday, November 3rd, 2022
TCEW 2	Tošin bunar	Thursday, November 3rd, 2022
TCEW 3	Bulevar umetnosti	Thursday, November 3rd, 2022
TCEW 4	Milentija Popovića	Thursday, November 3rd, 2022
TCEW 5	Savska	Tuesday, November 8th, 2022
TCEW 6	Kneza Miloša	Tuesday, November 8th, 2022
TCEW 7	Bulevar Oslobođenja	Tuesday, November 8th, 2022
TCEW 8	Maksima Gorkog	Tuesday, November 8th, 2022
TCEW 9	Vojislava Ilića	Tuesday, November 8th, 2022
TCEW 10	Ustanička	Tuesday, November 8th, 2022

The second phase of the methodological process included the preparation and training of researchers for the subject recording. This includes 70 researchers and 10 supervisors.

Figure 1. Research locations

The third phase of the methodology represents the implementation. The research was carried out using a manual data collection technique. For traffic counting, one

researcher per traffic lane was provided at each location, while the number of researchers was modified (reduced as needed) in locations with less traffic load. One researcher per direction was provided for recording vehicle occupancy at each location. In accordance with the research methodology, traffic was counted every hour during the researched day, while vehicle occupancy was recorded for the first 20 minutes of the observed hour. Traffic flow and vehicle occupancy was recorded in relation to vehicle categories. However, since the focus of this paper is the occupancy of passenger cars, only data on the passenger car counting and occupancy will be presented in the section results. When recording vehicle occupancy, in the case of passenger cars, the researchers entered the number of persons transported in each vehicle (from 1 to 5).

The fourth phase included data entry, analysis and presentations of the results. For the needs of this phase, special software was developed in which data on traffic counting and vehicle occupancy were entered separately. The main results are presented in the following chapter.

3. RESULTS, DISCUSSION AND RECOMMENDATIONS

In this chapter, only a part of the most significant results obtained by the research will be presented, bearing in mind the existing limitations in the scope of the paper.

At the very beginning, it is important to refer to the general characteristics of the traffic flow at the analyzed locations. Diagram 1 shows the average hourly traffic flow by location.

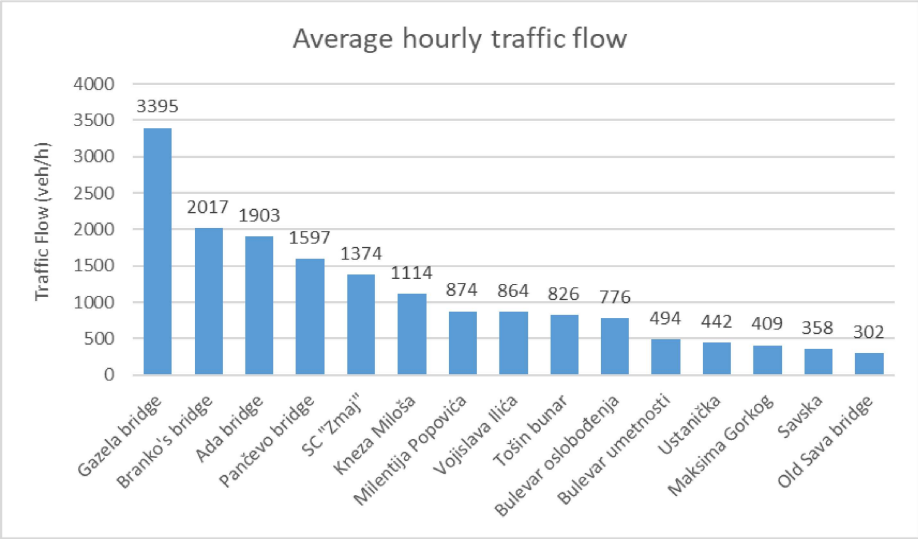

Diagram 1. Average hourly traffic flow for the analyzed locations

From the diagram, it can be seen that the bridges (with the exception of the Sava bridge) are the busiest connections, in Belgrade, with an emphasis on the Gazela bridge, which serves the largest number of vehicles during the day compared to the other locations.

Diagram 2 shows the average vehicle occupancy (AVO) by location. From the diagram, it can be seen that there are no significant deviations from the total average occupancy (1.47), except at the locations of Knez Miloš (1.73), which is also the location with the maximum AVO and Vojislav Ilić (1.64). The minimum AVO was recorded at SC "Zmaj" (1.34). What is important to note here is that locations where vehicle occupancy is higher than the overall average occupancy are actually important corridors that connect a large number of areas, that is, highly attractive parts of the city. Characteristic examples of such corridors are the locations Knez Miloš, Vojislav Ilić and Bulevar oslobođenja.

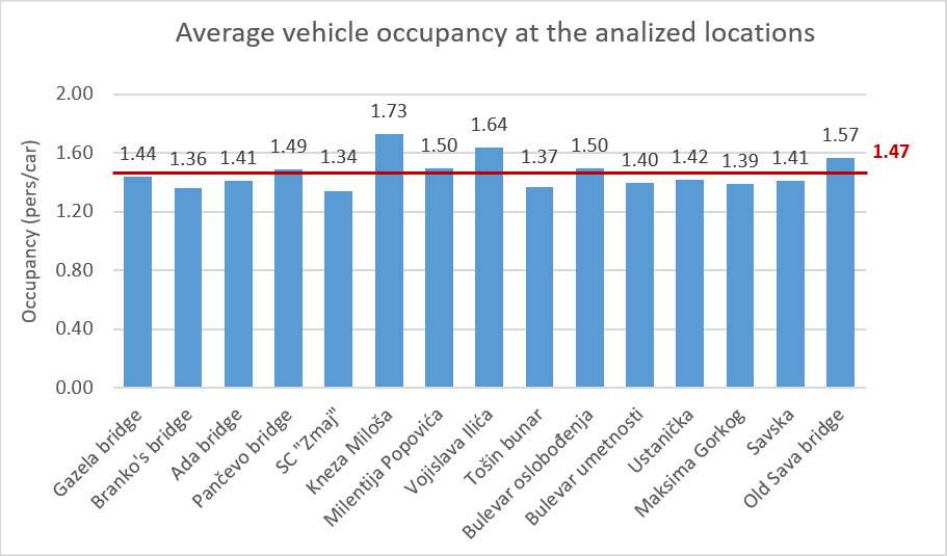

Diagram 2. Average vehicle occupancy at the analyzed locations

In order to observe some regularities, but also potential causes of differences in the AVO, the hourly fluctuations of this indicator are analyzed. Diagram 3 shows the results of AVO hourly fluctuations in four characteristic periods during the day.

The analyzed periods include the morning (7am-10am) and the afternoon peak period (3pm-6pm), as well as two off-peak periods (10am-3pm) and (6pm-10pm). From the diagram below, it can be seen that during the peak periods, a lower AVO of 1.36 and 1.39 was recorded, while off-peak periods are characterized by a higher AVO of 1.52 (10am-3pm), 1.58 (6am-10pm). Similar results were obtained in the research in Texas, where AVO of 1.49 (6am-10am) and 1.66 (3pm-7pm) were recorded, while in off-peak periods these values were 1.52 (midnight-6am), 1.78 (10am -3pm) and 1.81 (7pm-midnight) [6]. Such results are partly expected and can be interpreted in different ways, but what is worrying is the fact that during peak periods only 34% of vehicle capacity is used on average. For off-peak periods, this percentage is 39%, which indicates insufficient occupancy of passenger cars.

The previous results indicate that vehicle occupancy may have a certain dependence on the hourly traffic flow. However, on the basis of the conducted correlation analysis, a general conclusion about the existence of the aforementioned dependence cannot be made.

Analyzing the AVO by selected countries (Table 2) [7] it can be concluded that there is no apparent deviation from the total occupancy obtained in this paper (1.47). For example, the highest recorded average occupancy is in the USA (1.61), while the lowest measured value is in Denmark (1.42).

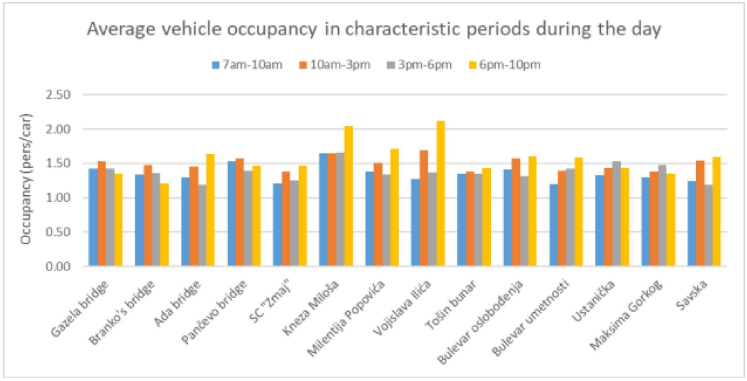

Diagram 3. Average vehicle occupancy in characteristic periods during the day

It is also interesting to note that the average occupancy of passenger cars in the EU is 1.7 people per vehicle [4], which only further emphasizes the fact that the majority of countries in Europe face the same problem.

Table 2. Passenger car occupancy by country

Country	USA	JP	CA	UK	FR	DE	IT	IN
PCO[1]	1.61	1.50	1.62	1.55	1.51	1.42	1.45	1.50

[1] PCO – Passenger car occupancy

This outcome should be used for the exchange of experiences and positive practices in order to develop the set of measures and recommendations for mitigating this problem. Table 3 shows the preliminary measures for potential solutions to overcome or at least mitigate the consequences caused by the LVO. These measures represent only a part of the general guidelines that should be further elaborated within the research.

Table 3. Proposed measures

Strategic and regulatory measures
Improvement of the existing regulation in order to provide Car pool, Car Share services, definition and use of HOV, HOT lanes.
Campaigns: about the advantages of Car pool, Car sharing services, and Public Transport, about combining tasks/jobs to avoid double trips, etc.
Personalized marketing initiatives to encourage users to plan the time and mode of travel/transport

Traffic-management measures	**Location of implementation**
Implementation of HOV lanes	TCNS 1, 2, 4, 5; TCEW 1
Implementation of HOT lanes	TCNS 4
Dynamic management of the yellow lanes in peak hours	TCNS 1, 2, 4; TCEW 7, 10
Implementation of Car pool and Car share services	City based
Road/street toll system for vehicles with an occupancy of less than 3 persons/vehicle.	City based

Strategic and regulatory measures	
Charges for entering the central city zones by vehicle	Central city zone
Increase in parking fees for vehicles with an occupancy of less than 2 persons/vehicle	City based
Reserved parking spaces at work, for users of the Carpooling system	City based

4. CONCLUSION

This paper presented the results of research conducted on 15 main corridors in Belgrade, through the analysis of two important parameters: traffic flow (traffic counting) and vehicle occupancy. Bearing in mind the various traffic problems faced by modern cities, the aim of this paper was to examine the current state of the mentioned traffic characteristics, and to propose potential solutions to overcome or at least mitigate the consequences caused by the low occupancy of passenger cars in correlation with their high presence on the street scene.

Bearing in mind the low overall AVO in the city (1.47), the measures are divided in two packages: strategic and regulatory measures and traffic-management measures, relative to the potential micro-location application. The given measures represent only part of the general guidelines that can be applied and should be defined on the basis of specific and detailed research and future strategic directions and policies of the city.

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