

# Analysis of the influence of the number of access points on the reduction of free – flow speed in Bosnia and Herzegovina

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**Abstract** – In this paper, an extensive analysis of the number of access points on a rural road network in the territory of Bosnia and Herzegovina has been performed. The HCM methodology defines that each access point adversely affects the speed of free traffic flow. The negative impact is quantitatively shown through 19 sections of rural roads, as well as a trend of reducing traffic flow speed on each of the analyzed sections. By analyzing and synthesizing the data, the values obtained indicate that access points affect reducing free traffic flow speed in the Federation of Bosnia and Herzegovina twice more than in the Republic of Srpska. The analysis also shows the spatial distribution of access points on the main roads section, which has been measured on 200 m subsections.

**Keywords** – access points, traffic flow, speed.

## I. INTRODUCTION

Each road section on a state road of the first or second order or highway has a dual role. The section must provide efficient traffic connections and enable accessibility to desired locations in the immediate vicinity of the road. Managing access points on road sections is a comprehensive process for regulating access points on state roads, i.e. a process for facilitating access to the site with developing usage while maintaining safety and efficiency on nearby roads.

A road network, as one of the elements of transport infrastructure, is a direct indicator of development level and as such it must have defined rules under which the owner (road manager) can put it into use, but also rules intended for users. Simply, no development of any economic activity is possible without a well-developed road infrastructure. [1]

The influence of access point control is different in terms of traffic conditions on rural and urban networks due to significantly different characteristics of traffic flow (including structure, complexity, time imbalances and traffic flow conditions), as well as the attractiveness of the site which should (not) be adequately accessed. Chaotic urbanization in the immediate vicinity of roads in Bosnia and Herzegovina is especially evident on two-lane roads and their passage through populated areas.

According to HCM (Highway Capacity Manual) (HCM-2010, HCM-2016) [2,3], the access point control is not given a

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primary role in defining the Level of Service, while domestic recommendations give a priority role to access control in defining indicators based on traffic safety. Therefore, a hypothetical assumption that the number of access points on two-lane roads is in complex functional dependence on the percentage of time lapse, safe visibility, driving and dynamic characteristics of vehicles and road characteristics (as well as the type of terrain) has been particularly emphasized.

## II. RESEARCH METHODOLOGY

According to their transport functions, public roads are divided into long distance, connecting, collection and access roads. [5,6] On the basis of the applicable Law on Fundamentals of Traffic Safety in Bosnia and Herzegovina [7], as well as the Law on Public Roads [8], two-lane roads, depending on their economic and social importance, are divided into:

- Main roads
- Regional roads
- Local roads and
- Streets in residential areas.

In this analysis, an empirical measurement was carried out on main roads of the first order by the method of observing in a moving vehicle. Using the method, it was measured the number of access points on the main road sections for every 200 meters of the measuring vehicle. In further work, the synthesis and processing of the obtained results is based on the corresponding HCM-2016 methodology for two-lane roads. Two-lane roads according to this methodology are divided into three classes. The application of the methodology is justified for roads of first and second class, but not for the third class (urban areas). By the method for calculating the free-flow speed based on the HCM methodology [2,3], the factor  $f_A$ , which is an indicator of the density of the number of access points on sections of two-lane roads, is of particular importance. Free speed, according to HCM-2010 and HCM-2016, is calculated by the following equation:

$$V_{sl} = V_{slo} - f_{bs} - f_A \quad (1)$$

where:

- $V_{sl}$  – free speed;
- $V_{slo}$  – base free speed;
- $f_{bs}$  – speed reduction due to the effect of lane width and distance of lateral obstructions;
- $f_A$  – speed reduction due to the effect of the number of access points (Table 1).

TABLE I  
EFFECT OF NUMBER OF ACCESS POINTS ON FREE SPEED  $f_A$  [3]

Density of access points (number of access points/mi)	Free speed reduction according to HCM-2016 per mile/h	Density of access points (number of access points/km)	Free speed reduction according to HCM-2016
0	0	0	0.0 (km/h)
10	2.50	16.09	4.0 (km/h)
20	5.00	32.18	8.0 (km/h)
30	7.50	48.27	12.0 (km/h)
40	10.00	64.37	16.0 (km/h)

The previous table, profiled by HCM-2016, provides an elemental indication that each access point reduces free speed by 0.25 mi/h (0.4023 km/h). These results are obtained by analogy, where every 10 access points per mile reduce free-flow speed by 2.5 mi/h (4.023 km/h). In HCM - 2010, the effect of the number of access points is included in the analysis of capacity and service level of two-lane roads over the same factor  $f_A$ , which defines that each access point reduces free speed by 0.417 km/h. [2,4] By applying the weighted access density using the HCM-2010 methodology, it yields better agreement between the values of the operating speed obtained by calculation and the real values recorded in the survey on the selected section of the two-lane road. The research has showed that the difference between the operating speed obtained by HCM and the real speed is 13.19 km/h, whereas if the weighted access density is introduced, the difference between the weighted operating speed and the actual operating speed is 1.72 km/h. [4]

It is also possible to make a realistic hypothetical assumption that the increased number of access points per kilometer of a

road adversely affects continuous traffic flow, reduces free speed and increases conflicts between vehicles. This paper has adopted the methodology for determining the number of access points on two sections of road given in HCM-2016 [3], analyzing the reduction of free speed for given sections, according to the results obtained by empirical research on 19 road sections of a rural road network.

### III. RESULTS OF THE RESEARCH

This paper analyzes the number of access points on 19 sections of main roads of first order, 10 sections in the Republic of Srpska and 9 sections in the Federation of Bosnia and Herzegovina. In this research, an access point means any type of access to a main road, where it is possible to approach the road by motor vehicles. In addition, fuel supply terminals were counted as two approaches, and bus stops were considered as one access point. Each intersection of the roads of the same category was viewed as a single access point, which is a disadvantage of this research since the private road and the road of higher category were classified as the same access point.

The results obtained show the number of access points per kilometer of the two-lane road and the number of access points along the left and right side of the two-lane road. Since the measuring vehicle measured every 200 m of the measuring section, the values of the number of access points on the left and right side were obtained by the data synthesis. Figure 1 shows the spatial distribution of the number of access points on the mountainous and, in Figure 2, the plain section, where a significant difference between the types of terrain is observed. It is also noticeable that there are significantly fewer access points in mountainous than plain observed area.

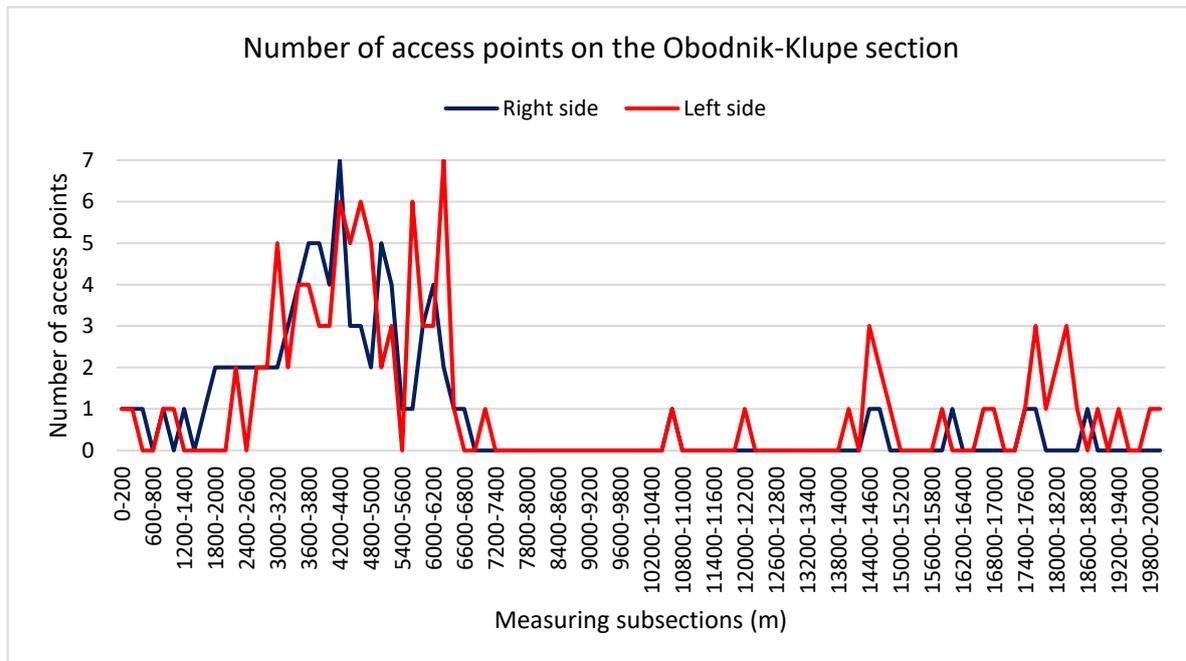


FIG 1. NUMBER OF ACCESS POINTS ON TWO-LANE ROAD SECTIONS IN MOUNTAINOUS TERRAIN

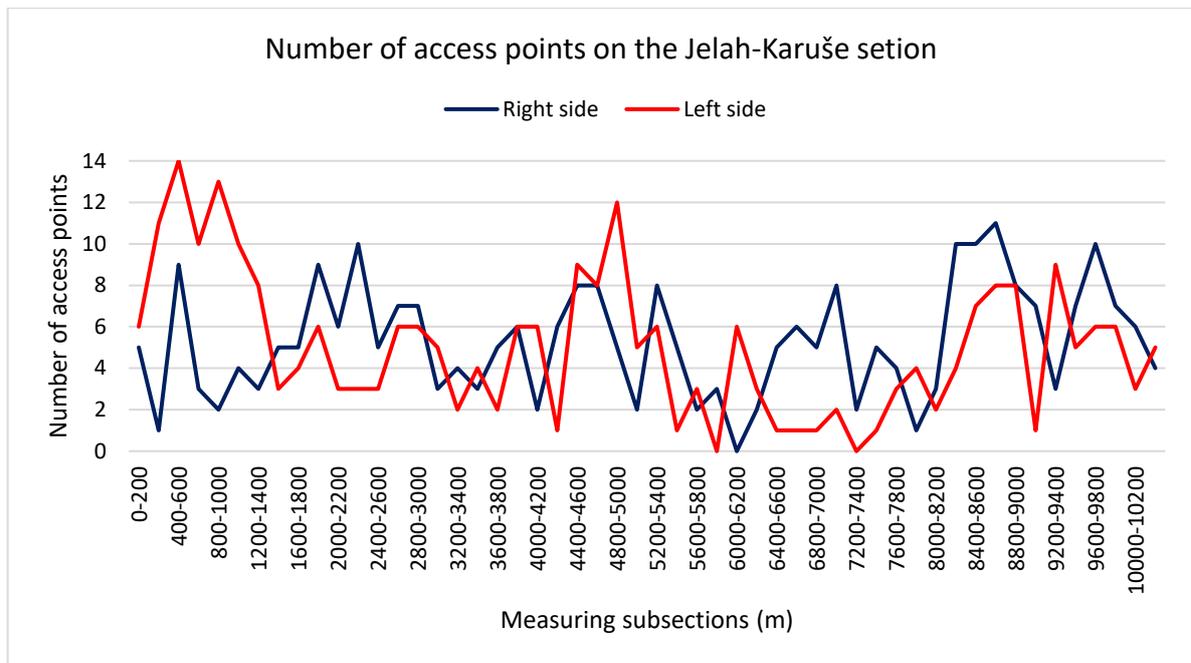


FIG 2. NUMBER OF ACCESS POINTS ON TWO-LINE ROAD SECTIONS IN PLAIN TERRAIN

Based on the distribution of access points given in Figure 1, the existing extremes reflect zones of residential areas with a frequent number of access points. Table 2 shows the number of access points by measuring subsections of 200 m, as well as the

arithmetic mean of access points of the given sections. This number of access points per kilometer ranges from the extremely low number of 2.47 (Klašnice-Prnjavor) to the extremely high number of 51.63 (Jelah-Karuše).

TABLE II.

ARITHMETIC MEAN OF THE NUMBER OF ACCESS POINTS AND THEIR EFFECT ON SPEED REDUCTION

No.	Section	Section mark	Section length (km)	AMAP/200m-right side	AMAP/200m-left side	AMAP/km	Road classes according to HCM 2016
1	Doboj Novi-Doboj (Poljice)	110	1.469	0.25	0.88	5.63	III class
2	Doboj (Poljice)-Border RS-FBiH	110	2.945	1.00	1.21	11.07	III class
3	Doboj-Border RS-FBiH (Karuše)	105	3.517	0.67	1.83	12.50	III class
4	Rudanka-Doboj	105	7.405	2.66	4.42	35.39	III class
5	Johovac-Rudanka	105	6.854	1.44	2.38	19.12	III class
6	Klupe-Teslić (Barići)	110	16.734	2.36	1.90	21.31	III class
7	Obodnik-Klupe	110	20.134	0.84	1.05	9.46	II class
8	Šešlije-Johovac	105	4.701	0.79	1.21	10.00	II class
9	Teslić (Barići)-Border RS-FBiH	110	6.646	2.15	1.97	20.29	III class
10	Klašnice-Prnjavor	106	35.855	1.03	1.44	2.47	III class
The mean value of the access points on given sections in the Republic of Srpska						<b>14.72</b>	
1	Donja Orahovica-Lukavac	110	20.155	1.66	2.33	19.95	III class
2	Gračanica-Donja Orahovica	110	6.89	3.29	5.14	42.14	III class
3	Border RS-FBiH-Gračanica	110	15.095	3.16	3.51	33.36	III class

4	Border RS-FBiH-Jelah	110	6.01	3.84	2.84	33.39	III class
5	Jelah-Karuše	110	10.265	5.29	5.04	51.63	III class
6	Karuše-Maglaj	105	19.03	2.45	2.15	22.97	III class
7	Lukavac-Šićki Brod 2	110	5.641	0.90	1.07	9.83	II class
8	Maglaj-Ozimica	105	10.520	1.30	1.74	15.19	III class
9	Ozimica-Žepče	105	6.187	1.39	1.39	13.87	II class
The mean value of the access points on given sections in the Federation of BiH						<b>26.93</b>	
The total mean value of the access points on given sections in Bosnia and Herzegovina						<b>20.82</b>	

#### IV. DISCUSSION OF RESEARCH RESULTS

The obtained research results show that there are significantly fewer access points in mountainous than in plain terrain. This decrease in access points in mountainous terrain can be explained by the fact that there are fewer settlements in mountainous terrain since those are mountainous rural areas, not tourist resorts.

In addition, the two-lane road sections of the Republic of Srpska have a significantly lower number of access points than in the Federation of BiH. The obtained results show that the number of access points (26.96 AP/km) in the Federation of BiH is almost twice higher than in the territory of the Republic of Srpska (14.72 AP/km). The number of access points also has the effect of reducing the speed of free traffic flow. Free-flow speed in a function dependence on the number of access points reduces free speed on RS roads by 3.78 km/h (Obodnik-Klupe) and in the Federation of BiH by 3.93 km/h (Lukavac-Šićki Brod 2) according to HCM-2016, since these are class II rural roads. According to the research on 19 sections, the average number of access points in Bosnia and Herzegovina is 20.82 AP/km, which shows that their number is extremely high and that it significantly affects the reduction of free traffic flow speed on average.

#### V. CONCLUSION

Based on the conducted research, analysis and synthesis of the collected data, it can be concluded that the number of access points has increased in the zones of populated areas. In addition, on the basis of HCM methodology, it is shown that each access point has the effect of reducing the free-flow speed, deteriorating traffic safety due to the increased number of conflicts, impeding the continuity of traffic flow, etc. On the basis of the above, the hypothetical assumption that the increased number of access points per kilometer of road adversely affects the continuous traffic flow, reduces free speed and increases conflicts between vehicles has been proved.

The research has also proved that a significantly higher number of access points on two-lane roads are in the Federation of BiH than in the Republic of Srpska. This trend needs to be addressed by regulatory plans and the prohibition of unfounded construction of accesses on a main road network. In the next period, special attention should be paid to monitoring an

increase in the number of access points due to the negative trend on the observed roads. The unfavorable trend of increasing the number of access points requires detailed realistic field recording on all sections of two-lane roads. It is especially important to create a single database of their number, which would be input parameters for planning, design and operational analyzes.

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