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STRUCTURING OF ROAD TRAFFIC FLOWS

ABSTRACT

Systemic traffic count on the Croatian road network has been carried out for more than three decades in different ways. During this period a large number of automatic traffic counters have been installed, and they operate on different principles. The traffic count has been analyzed from the aspect of vehicle classification. The count results can be only partly compared since they yield different structures of traffic flows. Special analysis refers to the classification of vehicles by automatic traffic counters.

During the research, a database has been formed with physical elements of vehicles of over five thousand vehicle types. The research results prove that the vehicle length only is not sufficient for the classification of vehicles, the way it is used in the present automatic traffic counts, but rather the number of axles, the wheelbase as well as the front and rear overhangs need to be considered as well. Therefore, the detector system should apply also the detector of axles.

The results have been presented that were obtained as part of the program TEST – Technological, research, development project supported by the Ministry of Science, Education and Sport.

KEY WORDS

traffic count, traffic flow, traffic flow classification

1. INTRODUCTION

Traffic count consists of systemic collection of data on traffic load and the traffic flow structure, as well as spatial and temporal traffic variations on the road network. The basic information on traffic represents the necessary assumption for the development and implementation of an efficient traffic policy. It is impossible to think of the economically and technically rational management of road traffic system without having precisely determined data on the traffic volume and composition of traffic flows.

In the three last decades a rich collection of data on traffic load on the Croatian road network has been formed, especially data obtained from the automatic counters, which enable different researches both in the area of the methodology itself, as well as the development of prognostic models, traffic trends and the similar. From the beginning of the systemic traffic counts in our country, their development has been constantly improved as well as the development of the data processing system. The development of road traffic and total traffic system require high-quality information on traffic, which imposes the need for constant expansion and improvement of the traffic count system. One of the important aspects of traffic count is to determine the traffic flow structure. The purpose of this work is the critical analysis of the traffic count system on the Croatian road network precisely from the aspect of the classification of vehicles in the traffic flow and the application of the authors' research results.

2. PRESENT METHODS OF FLOW STRUCTURING

2.1. Methods of traffic counts

The systemic and constant collecting of data on road traffic in Croatia started in 1971 manually. Until the year 1973 the data on traffic count were processed manually, and after that by computers. The first turn in the traffic count was the introduction of stationary automatic traffic counters in 1978. After the first motorway in the Republic of Croatia was opened on the Zagreb-Karlovac section, the so-called toll traffic count was introduced in 1973, and it expanded together with the development of the motorway network, as well as on other toll charging road structures: the "Krk" bridge and the "Učka" tunnel. In 1980 started the collection and publication of the data on carriage of road vehicles by ferries. Adequate data on the transported vehicles are kept by the organizations that operate the ferries. They register the number and the structure of the carried vehicles per ferry lines. The essential development in the volume, organiza-

tion in collecting and processing the data was made in 1980, when the integral traffic count system was designed and implemented, and it combined different data collection methods and integrated the processing results into a single publication. The traffic count is carried out in accordance with the Recommendations of the Internal Traffic Board of the European Economic Commission of OUN (UN/ECE). Portable automatic traffic counters were introduced in 1997 and from then started the occasional automatic traffic counts. Manual traffic counts stopped to be used any more except at locations of traffic counts by means of automatic counters of the older generation.

From the very beginning of traffic counts, apart from the accuracy of results depending on the counting method, one of the key problems has been the determining of the traffic flow composition. Every method of traffic count features different ways of determining the type of vehicle in the traffic flow, which depends on the technical and technological possibilities of single counting methods, which results in big problems in applying the data. The paper analyzes the characteristics of single count methods from the aspect of traffic flow structuring.

2.2. Automatic traffic count by stationary counters

The stationary automatic counters are used for continuous traffic counts the whole year round. The data collection point is the counting location. There are several generations and types of counters in service. Their common characteristic is that they record the traffic volumes cumulatively in given intervals and per lanes, which in case of two-lane roads means at the same time traffic per directions. Three types of counters are in service: SBH/DL 2000, Peek Traffic ADR-2000 and Mikrobit QLD-6CX [1]. Further in the text the main characteristics of single counter types are described from the aspect of vehicle classification.

Automatic traffic counters Signalbau-Huber, type SBH/DL 2000

The first stationary automatic traffic counters of type SBL/DL 2000 of the company Signalbau-Huber GmbH from Germany were installed during the mid-seventies of the last century. The vehicles are detected by means of an inductive loop embedded in the lane carriageway. Figure 1 shows an inductive loop of 2×2 m dimensions.

Originally, the counters registered the passage of a smaller vehicle as passage of one equivalent vehicle unit, and passage of a truck with a trailer, tractor-trailer and a similar vehicle as passage of two or three equivalent vehicle units. The improvements on

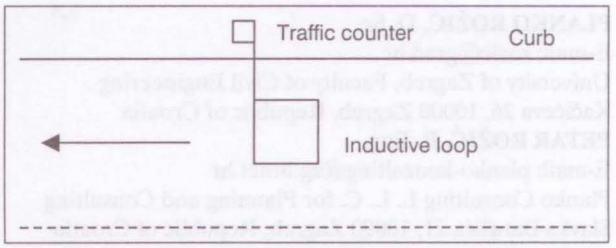

Figure 1 - The position of the inductive loop in the lane

the electronic unit in 1997 enabled the counters to register the passage of one vehicle as one unit, and then occurred the problem of transforming these units into the number of actual vehicles. The structure of traffic flow had not been determined until the year 1984, but the data from the closest or similar locations of manual traffic count were used. The structure of traffic flow is then determined by manual count within a selected time sample. The vehicles are classified into nine groups: motorcycles, passenger vehicles, commercial vehicles of total weight of up to 3.5 t, buses, commercial vehicles of total weight from 3.5 to 7 t, commercial vehicles of total weight over 7 t, commercial vehicles with trailers, tractor trailers, and agricultural tractors and working vehicles.

Automatic traffic counters Peek Traffic, type ADR-2000

The automatic counters of the Peek Traffic company, manufactured in Great Britain, are the first counters of the newer generation installed on our roads in 1998. The detection system consists of two inductive loops embedded in every traffic lane, as presented in Figure 2.

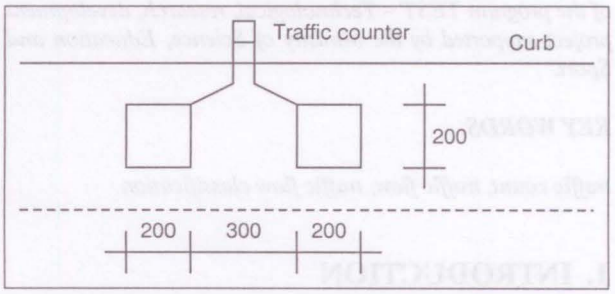

Figure 2 - Detection system with two inductive loops in a single lane

Such detector configuration allows measuring of the vehicle speed and its length and in this way the counters distinguish the vehicles according to the determined classes of their lengths and classify them into appropriate groups, without recognizing the vehicle types. The data processing gives the classification of vehicles in five groups according to their lengths: vehicles of lengths up to 5.5 m, from 5.5 to 9.1m, from 9.1 to 12.2 m, from 12.2 to 16.5 m and over 16.5 m. At three count locations the system of weighing the vehicles in motion is tested - WIM system (Weight-in-Mo-

tion). The detection system in every lane consists of two inductive loops and one piezo sensor which detects the vehicle axle weight, and is embedded in the carriageway transversally to the lane between the two loops. Generally, this solution has not proven successful in our conditions, and besides the question of calibrating and certifying the axle detector i. e. axle load remains unanswered.

Automatic traffic counters Mikrobit, type QLD-6CX

As a pilot project, three stationary automatic counters Mikrobit, type ADR-2000 imported from Slovenia were installed on motorways in the first part of the year 1999, and from the year 2001 the installation of these counters continued, and they were distributed on the network of state roads. Apart from other characteristics, these counters can classify the counted vehicles into certain types and sub-types. These counters also detect the vehicles by means of two inductive loops in a single lane. The counters have the possibility of classifying the vehicles into nine groups: motorcycles, passenger vehicles, passenger vehicles with trailer, vans with or without trailers, smaller commercial vehicles, medium commercial vehicles, heavy commercial vehicles, commercial vehicles and tractors with trailers and semi-trailers, buses, all the unidentified i. e. unclassified vehicles.

2.3. Occasional count using portable automatic counters

Occasional counts are applied if information about the traffic on road sections that have not been included in continuous automatic counts are required, and these are used in numerous countries. The counting takes several days, and for this the determining of the count schedule during the year is crucial. This is possible only through simulation on a relatively large sample consisting of databases of continuous automatic counting from the available period, usually in a series of three or more years.

Automatic counters Nu-Metrics, type NC - 90A

In 1997 a great novelty occurred in the traffic count system on our roads, when the portable automatic traffic counters were introduced, of the U. S. company Nu-Metrics, model NC-90A intended for occasional counts. Such counts were completely new, both regarding the count schedule during the calendar year, and regarding the method. The counter features the dimensions 30x14x1.5 cm and is fixed onto the carriageway surface within the lane. The vehicles are detected on the principle of the change in the magnetic field and are classified into five groups regarding the vehicle length: vehicles of up to 5.5 m in length, vehicles from 5.5 to 9.1m, from 9.1 to 12.2 m, from 12.2 to 16.5 m and over 16.5 m. The counters classify the vehicles according to their lengths and it is not possible to determine exactly which type the counted vehicle belongs to.

2.4. Traffic count on toll road structures

Toll road structures are special facilities at which the right of passage is specially charged. In the Republic of Croatia this includes the motorway network, the "Učka " tunnel and the "Krk" bridge. This type of traffic count is in fact no count in the classical sense of the word, since it is performed by using the data from the toll system, which is organized primarily for financial requirements. Unlike other count methods, it is easy to determine not only the traffic volume at the individual toll booth, but also per sections, and the traffic flow composition is also easily recorded. The vehicles are classified into five groups: vehicles with two axles except for vans, of the height up to 1.30 m measured at first axle, vehicles with three or more axles including also the vans, of height up to 1.30 m measured at the first axle, vehicles with two or three axles including vans with trailers, of height greater than 1.30 m measured at the first axle, vehicles with four or more axles, of height greater than 1.30 m, measured at first axle and vehicles that are exempted from payment or those whose passage is charged separately.

2.5. Ferry-carried vehicles counts

Vehicle count on ferry lines is a special type of toll count. In Croatia only data on the transport of vehicles per domestic lines per single types of vehicles are monitored and processed, performed by the companies that also organize the transport of vehicles. The vehicles are classified into four groups: passenger vehicles, buses, trucks with or without trailers and tractor-trailers as well as other vehicles. The data are processed and presented per months in a year and consequently the AADT (Average Annual Daily Traffic) and summer ADT (Average Daily Traffic) are calculated, the total for all vehicles together and per each type of vehicle separately.

3. PROBLEMS OF FLOW STRUCTURING

One of the biggest drawbacks of structuring the traffic flow on our roads is that there is no consistency in classifying vehicles into identical groups in different count methods. The main characteristic of stationary and portable counters is that the vehicles are classified into groups according to their lengths. In such classification it is impossible to determine precisely the type of the counted vehicles. Therefore, the publication on

the road traffic count gives the instruction for the estimate of the share of single types of vehicles in groups. Such approach is not acceptable from the traffic and technological point of view.

The traffic flow structure, namely, has multiple significance in the engineering practice, both from the traffic aspect and from the construction aspect. The different flow composition affects differently the traffic flow condition. Heavy commercial vehicles with their dimensions and driving-dynamic characteristics may impose driving conditions and flow condition. Their influence is variable and depends on the traffic volume, type of road and road elements. At low traffic volume on a two-lane road with good elements the faster vehicles will be able to overtake the slower ones, which are usually the heavy commercial and recreation vehicles. The possibility of overtaking is reduced with the increase of traffic load. A road with elements that cause reduced possibility of overtaking or completely eliminate it, can result in poor condition of the traffic flow even in case of low volume level, since they reduce the speed of vehicles below the level acceptable by the drivers, causing frustration in drivers who would want to overtake the slower vehicles and thus influence the traffic safety as well. From the construction point of view, the participation of heavy commercial vehicles in the traffic flow affect directly in case of dimensioning the new carriageway structures, as well as in case of maintaining the existing carriageways. Due to their negative impact on the traffic flow, the movement of heavy commercial vehicles is banned during certain intervals on the main sections of the road network. This shows clearly that the traffic flow structure has direct influence on the overall management of the road traffic system.

Many countries apply different classifications of vehicles in the flow. Thus, e. g. the U. S. Federal Highway Administration foresees a classification of 13 types of vehicles:

1. motorcycles,
2. passenger cars,
3. other two-axle vehicles with four wheels,
4. buses,
5. two-axle trucks with six wheels,
6. three-axle trucks,
7. trucks with four and more axles,
8. tractors with semi-trailers with maximally four axles,
9. tractors with three axles and semi-trailer with two axles,
10. tractors with three axles and semi-trailer with three or more axles,
11. tractors with two trailers with a total of five or fewer axles,
12. tractors with two trailers with a total of six axles,
13. tractors with two trailers with a total of seven or more axles.

Two more classes could be added here. These are the class that can be determined by the user and the class which includes all the vehicles that do not enter into any of the 13 classes. According to the provision given by the European Economic Commission, the vehicles can be classified into 25 + 5 classes. The common characteristic of these classifications is that the vehicles are mainly divided regarding the number of axles and not according to length.

The preliminary study of certain types of vehicles and their length in different technical sources has questioned the credibility of the classification of vehicles exclusively according to the parameters of their length. It was, namely, proven that an entire series of vehicles that have similar or equal lengths can actually be different types of vehicles. At the same time, it was found out that apart from the vehicle length, a very important parameter is also the disposition of the vehicle elements: wheelbase, length of the front overhang, and length of the rear overhang. A research was started in which the relevant literature with technical data on vehicles was collected, and the key data for the description of the physical properties of vehicles have been selected:

- number of axles,
- wheelbase,
- total vehicle length,
- length of the front overhang,
- length of the rear overhang,
- total vehicle weight,
- number of seats,
- vehicle category,

A special form for entering the data was created according to the mentioned elements. A database about vehicles [2, 3, 4, 5] was created from different sources, depending on the type of vehicle. All the sources have long years of reputation as the leading technical literature in the respective field in the world, and the literature of the Croatian Vehicle Centre (Centar za vozila Hrvatske) has been consulted as well [5]. For each vehicle a database has been formed with the vehicle elements as presented in the example of the 2-axle truck of total mass from 10 to 14 t in Table 1.

The vehicles have been classified into characteristic classes within which a whole series of vehicle types has been processed as presented in Table 2.

Table 2 shows that a total of 5496 different types of vehicles have been analyzed. These basic categories may be further expanded by different combinations of vehicle groups composed of tracting with trailed vehicles. The database consists of all the latest vehicle types. The sources, namely, that are used to create the

Table 1 - Part of the database with vehicle elements

Ord. No.	Number of axles	Wheel-base (mm)	Total length (mm)	Front overhang (mm)	Rear overhang (mm)	Total mass (kg)	Number of seats	Vehicle category	Type of vehicle
	2	4815	8520	1200	2505	12000	2	10 - 14 t	IVECO D/I, ML120EL21/P

Source: Authors' research

Table 2 - Overview of the vehicle types per characteristic vehicle groups

Ord.No,	Vehicle classes	Number of vehicle types in the class
1.	Motorcycles	**659**
1.1.	Motorcycles above 250 ccm.	343
1.2.	Motorcycles of 125 ccm.	51
1.3.	Scooters from 49 to 638 ccm.	265
2.	2-axle vehicles	**4040**
2.1.	2-axle passenger cars	1928
2.2.	2-axle personal caravan vehicles	232
2.3.	2-axle supply vehicles	597
2.4.	2-axle AWD vehicles of total mass to 3.5 t	224
2.5.	2-axle trucks of total mass from 3.5 to 6.5 t	58
2.6.	2-axle trucks of total mass from 6,5 to 10,0 t	94
2.7.	2-axle trucks of total mass from 10.0 to 14.0 t	98
2.8.	2-axle trucks of total mass from 14.0 to 19.0 t	427
2.9.	2-axle tractor of semi-trailers of total mass up to 3.5 t	2
2.10.	2-axle tractor of semi-trailers of total mass above 3.5 t	231
2.11.	2-axle AWD vehicles of total mass above 3.5 t	175
2.12.	2-axle minibus	65
2.13.	2-axle tourist coach	44
2.14.	2-axle city and line bus	65
3.	3-axle vehicles	**584**
3.1.	3-axle trucks of total mass from 20,0 to 39,0 t	437
3.2.	3-axle tractor trailers of total mass from 26.0 to 33.5 t	128
3.3.	3-axle tourist coaches	8
3.4.	3-axle city and line buses	11
4.	4-axle vehicles	**186**
4.1.	4-axle trucks of total mass from 28.0 to 42.0 t	185
4.2.	4-axle buses	1
	Total – types of vehicles	**5469**

Source: Authors' research

database are updated annually with the appearance of new types of vehicles.

The research results regarding the elements of over five thousand types of vehicles indicate that:

1. there is no clear margin between the lengths of individual types of vehicles classified per total mass or load capacity. The increase in the vehicle length, namely, does not correlate linearly with the total

mass or loading capacity of a vehicle, but rather the lengths of different types of vehicles tend to overlap;

2. the number and disposition of the vehicle axles form a significant feature in the description of a vehicle. They allow clear distinction between the heavy commercial vehicles from other commercial vehicles, the same as the passenger cars from the light commercial vehicles;
3. there is a connection between the wheelbase of the two-axle vehicles and their relation towards the total length of the vehicle, which can also be an important parameter in the classification of two-axle vehicles;
4. the front and rear overhangs, and especially the front ones can also help in the fine division of two-axle vehicles;
5. the classification of vehicles must include also the number and the disposition of vehicle axles.

4. CONCLUSION

Based on the analysis of traffic flow structuring, it may be concluded that the method of classifying vehicles into nine groups of vehicles based on short-term samples of manual counts is not acceptable, as in the case of the traffic counter Signalbau-Huber, type SBH/DL 2000, nor is the traffic flow structuring in five groups of vehicles based on the vehicle lengths acceptable, as in the case of the stationary traffic counters Peek Traffic, type ADR-2000 and portable traffic counters Nu-Metrics, type NC-90A. The research has showed that the classification of vehicles in the traffic flow based only on the vehicle lengths does not yield unambiguous results, but the number and disposition of vehicle axles have to be included as well. The stationary counters Mikrobit, type QLD-6CX have been recently installed and their operation cannot be assessed precisely yet. The vehicle classification on toll charging facilities and ferry lines has not been harmonized yet with other methods of vehicle division, since it is based on financial rather than traffic requirements.

It may be generally concluded that the research has proven that the existing traffic count system does not yield satisfactory classification of traffic flows and that it is not unique at the system level, thus resulting in problems in implementation, and that the system only partly meets the traffic and construction requirements.

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SAŽETAK

STRUKTURIRANJE PROMETNOG TOKA

Sustavno brojenje prometa na cestovnoj mreži Republike Hrvatske provodi se više od tri desetljeća na različite načine. U tom je razdoblju instaliran veliki broj automatskih brojila prometa, koja rade na različitim principima. Načinjena je analiza brojenja prometa sa stajališta klasifikacije vozila. Rezultati brojenja mogu se samo djelomično uspoređivati jer daju različite strukture prometnoga toka. Posebno je analizirana klasifikacija vozila automatskim brojilima prometa.

Tijekom istraživanje formirana je baza podataka s fizičkim elementima vozila za above pet tisuća tipova vozila. Rezultati istraživanja dokazuju da samo duljina vozila nije dovoljna za klasifikaciju vozila, kako se to radi u postojećem automatskom brojenju prometa, već se moraju uključiti i broj osovina i njihov razmak, kao i prednji i stražnji prijepusti. Zbog toga je u detektorskom sustavu potrebno primijeniti i detektor osovina.

Prikazani rezultati nastali su u okviru programa TEST – Tehnologijski istraživačko-razvojni projekti uz potporu Ministarstva znanosti, obrazovanja i športa.

KLJUČNE RIJEČI

brojenje prometa, prometni tok, klasifikacija prometnog toka

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