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Surveying of Traffic Congestions on Arterial Roads of Kyiv City

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Abstract

It's represented the result of survey performed by department of airports and highways reconstruction of National Aviation University. The traffic congestions on arterial roads of Kyiv was analyzed on the base of the survey performed.

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1. Actuality of the subject matter

Effective street network functioning in any human settlement must meet the requirements of all traffic participants: transport vehicle's drivers, passengers, pedestrians, bicyclists, traffic managers, and local public authority. In other words, the main purpose of proper city street network operation is to satisfy in the best way the demands of citizen in transport services. The solution of such type questions depends mainly from ability to ensure convenient and safety conditions for traffic.

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2. Problem solution

The main technique to make the of street network operation effective is to find, study and analyze the reasons and points on the arterial roads where deterioration of traffic conditions including congestions takes place [1]. The street network of Kyiv was selected to conduct experimental investigations of such kind.

Deterioration of traffic conditions in Kyiv began in the middle 90s of past century. The first congestions occurred in central part of city while middle and peripheral ones had certain traffic capacity reserve to pass by the traffic jam areas.

But at the beginning of 2000s, the number of motor vehicles became grow rapidly and it had caused in middle part of city as well. For the last 10 years the traffic situation along the arterial roads of Kyiv has begun to get worse and traffic congestions are already formed in peripheral city areas even.

The last has complicated the traffic on a new complexity level. That means that it was possible earlier to pass by the traffic jam in the central part of the city or local traffic congestion in its middle area just through other streets with free traffic. But now there can be situations when traffic congestion covers the whole city street network.

According to the Master plan of city development for Kyiv and its suburban area by the year 2025, the total length of its arterial roads must be increased by 1.4 times. That makes it possible to use their traffic capacity more effectively and avoid road congestion.

The arterial road system of Kyiv, despite its low development level, contains over 100 transport hubs. As a rule, hubs cause the traffic density increase in neighboring arterial roads up to traffic congestion level sometimes. That's why, the experimental studies of arterial road network state are necessary to analyze further the transport situation within the street network of Kyiv.

The traffic congestion surveys in Kyiv street network were carried out on the department of airports and highways reconstruction of National Aviation University from November 2014 to May 2016.

The traffic congestions were studied within the central, middle and peripheral zones of Kyiv street network, Fig. 1 [2]:

- Central zone (inside the closed curve including the European square—the Lvivska square—the Peremoga square—the “Ukraine” palace—the Lesi Ukrayinky square—the Slavy square—the European square);
- Middle zone (bounded by transport hubs: the Sevastopolska square—the Moskovska square—the Lybidska square—the Paton bridge—the Darnytska square—Gagarina street—Bratislavska street, Vatutina avenue—Moskovskiyi bridge—Moskovskiyi avenue—Olena Teliga street—Dovzhenko street—V. Getmana street—Chokolivskiyi boulevard—the Sevastopolska square);
- Peripheral zone (located outside the closed curve of middle zone boundary).

December represents the most complicated month of traffic congestion period. The average monthly traffic congestion index at that time amounts to 4.6 due to pre-holiday rush. The lowest traffic congestion level corresponds to July, August and January due to summer and winter holidays. The average monthly traffic congestion index at that time amounts to 2.2. The distribution of average monthly traffic congestion on the streets of Kyiv during a day is represented on Fig. 2. The summer investigations were carried out in June–August 2015, and winter investigations were carried out from December 2015 to February 2016.

The longest traffic congestions occurred in 2015 year are the following:

- on the 5-th of February at 09.40 (9.4 km long one from beginning of Brest–Lytovsky highway then along Peremogy avenue up to at-grade intersection with Mykola Vasylenko street);
- on the 5-th of February at 10.30 (10.4 km long one from at-grade intersection of Olzhycha street and Oleny Teligy street then along Moskovsky avenue and general Vatutin avenue up to At-Grade Intersection with Volodymyr Mayakovsky avenue);
- on the 20-th of March at 10.30 (10.7 km long one from grade separation of Borshchagivska street and Vadym Getman street then along Oleksandr Dovzhenko street, Oleny Teligy street and Moskovsky avenue up to Moskovsky bridge).

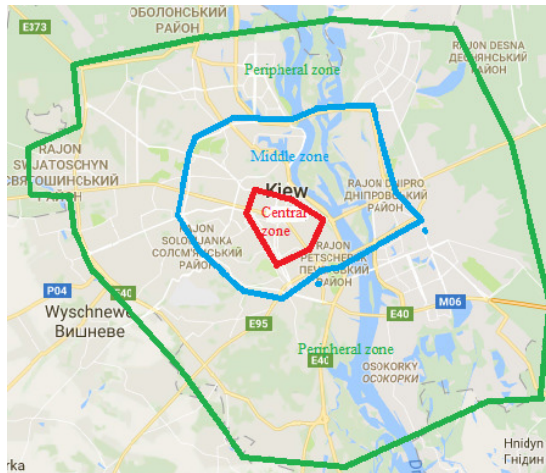


Fig. 1. Division of Kyiv city territory into zones.

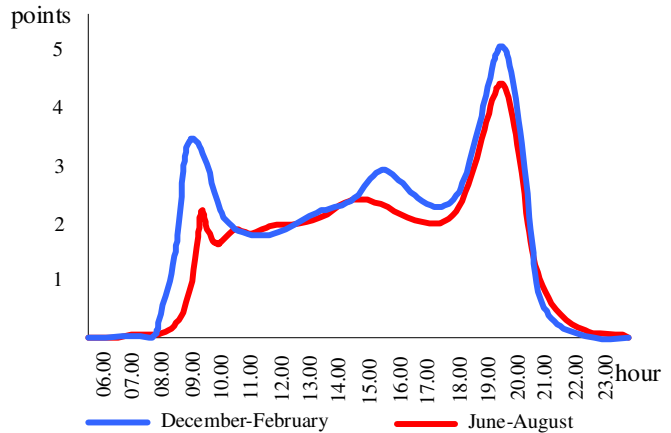


Fig. 2. The distribution of average monthly traffic congestion on the streets of Kyiv during a day.

The state of traffic congestion analyzed on the arterial roads of Kyiv enabled to define the following characteristics: average traffic congestion length, total traffic congestion length taking into account the lane number, average number of traffic congestion zones.

Analyzing the average length of traffic congestion formed during a day within territorial zones described above, one may state that in Kyiv the traffic congestion number of average length in its central zone accounts for 26.0% from the total number of average length traffic congestions while in its middle and peripheral zones such type percentage accounts for 44.4% and 29.6% respectively. The average length of traffic congestion in central zone of Kyiv accounts for 7 km while in its middle and peripheral zones 12 km and 8 km respectively.

It should be noted that traffic congestions variate during a day in a following way (Fig. 3): the shortest length of traffic congestion occurs from 7.00 to 8.00 a.m and accounts for 2% of the whole length of traffic congestion during a day, while the longest traffic congestions occur from 08.00 to 09.00 a.m. and from 6.00 to 7.00 p.m. and accounts for 16% and 23% respectively (Table 1). Depending on the territorial zone, the length of traffic congestions variates during a day in following manner:

- the central zone: in a morning it accounts for 3.3 km (13.7%), in the afternoon, – 8.7 km (38.5%), in the evening, – 7.9 km (23.9%);

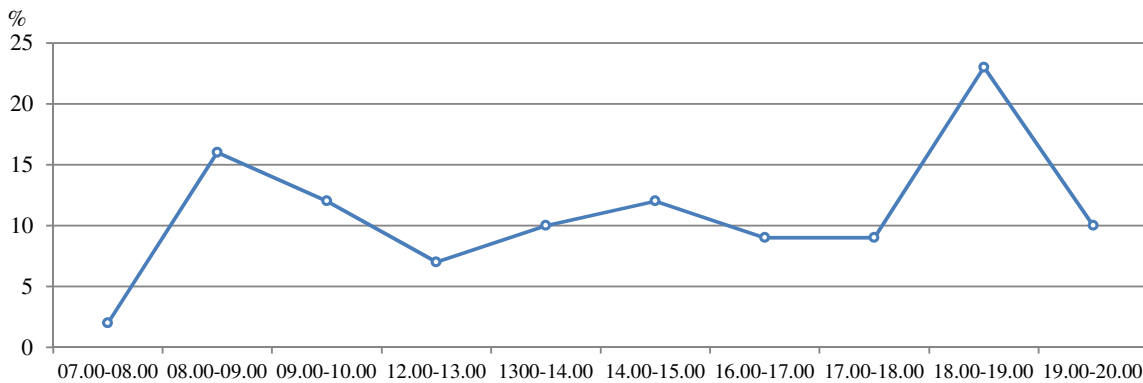


Fig. 3. Ratio of traffic congestion lengths to certain time period during the day.

- the middle zone: in a morning it accounts for 10 km (41.7%), in the afternoon, – 10.9 km (48.2%), in the evening, – 15.05 km (45.8%);
- the peripheral zone: in a morning it accounts for 10.7 km (44.6%), in the afternoon, – 3 km (13.3%); in the evening, – 10 km (30.3%).

Table 1. Average length of traffic congestions in Kyiv.

Time	Average length of traffic congestions						
	Central zone		Middle zone		Peripheral zone		Total in city
	meter	%	meter	%	meter	%	meter
08.00		0	1600	34.4	3050	65.6	4650
09.00	5450	14.2	15250	39.8	17650	46.0	38350
10.00	4350	15.0	13150	45.4	11450	39.6	28950
13.00	5800	36.0	8400	51.7	2000	12.3	16250
14.00	8800	37.1	13300	56.1	1600	6.8	23700
15.00	11300	40.9	11000	39.8	5350	19.3	27650
17.00	6300	30.4	10150	49.0	4250	20.5	20700
18.00	5220	24.1	10900	50.5	5500	25.5	21600
19.00	12250	21.9	24100	43.1	19550	35.0	55900

As it follows from table 1, the traffic congestions in central part of city are completely absent till 8 a.m. while in peripheral zone they accounts 65.6%, but after 9 a.m. the number of traffic congestions and their average length become growing rapidly and at 13.00 o'clock they exceed the corresponding indices of peripheral zone and in period from 14.00 to 15.00 o'clock they exceed the corresponding indices of middle zone even: central part, 11.3 km (40.9%), middle zone, – 11 km (39.8%), peripheral zone, – 5.35 km (19.3%). The histogram of average traffic congestion length per hour for arterial roads of Kyiv is represented on Fig. 4.

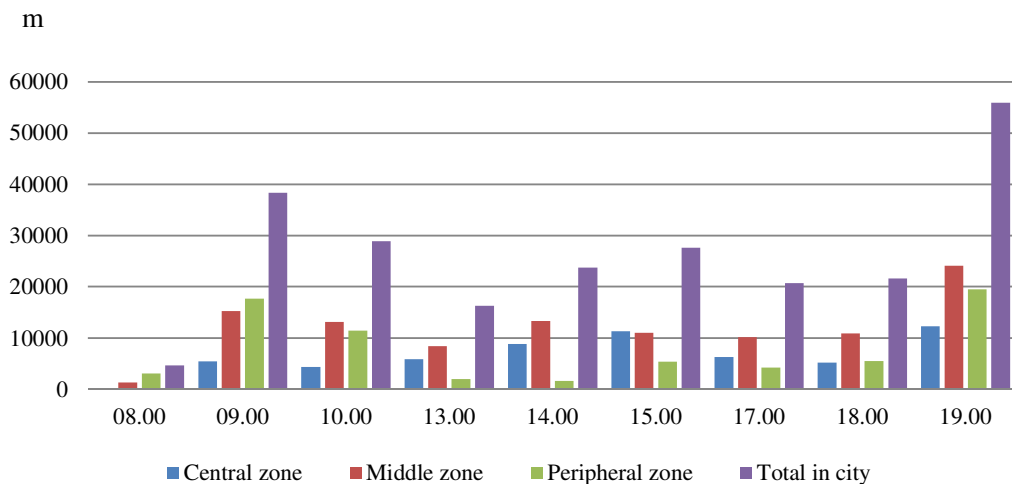


Fig. 4. The average traffic congestion length per hour for arterial roads of Kyiv taking into account its territorial zones.

The average length of traffic congestions in Kyiv, taking into account the number of traffic lane, accounts for 67 km. In the most loaded traffic period from 18.00 to 19.00 o'clock this value accounts for 142.8 km. The number of vehicles in any traffic congestion can be determined by dividing the length of traffic congestion by the dynamical

length of a vehicle (assumed about 8–10 m). This means that on average about 7500 cars usually move in traffic congestions and in the most loaded traffic period (rush hour) the number of such cars increase up to 15800 vehicles. The results of such type traffic congestions survey are represented on Fig. 5 where diagram illustrates the dependence of total traffic congestion length from time period of a day taking into account the traffic lane number.

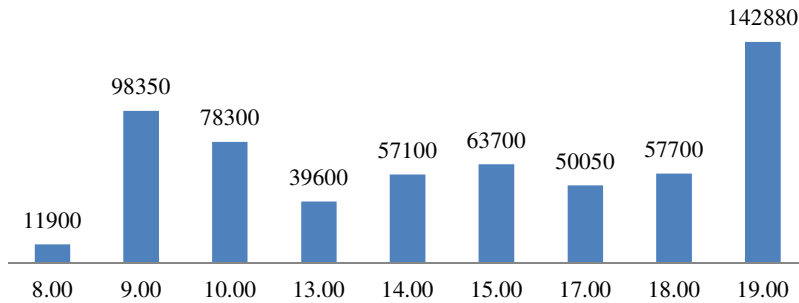


Fig. 5. Total length (m) of traffic congestion taking into account the traffic lane number.

By analyzing the number of traffic congestion areas along the arterial roads of Kyiv, the main attention should be paid to the places where deterioration of traffic conditions and traffic congestion take place during the whole working day.

According to the data obtained during the survey, it was determined the average number of traffic congestions along the arterial roads of Kyiv in each its territorial zone: the central zone – 7 areas, middle zone – 17 areas, peripheral zone – 13 areas, and total number is 37 areas. The traffic congestion numbers depending on the survey time and territorial zone of their location are represented on Fig. 6.

The next characteristic to perform the survey was the dependence of traffic congestion from category of arterial road. The survey performed and analyses of traffic congestion areas enable to conclude the following: about 55% of all traffic congestions occur on general city arterial roads where average length of such congestions accounts for 15.2 km; 44% – on city district arterial roads where average length of such congestions accounts for 12.0 km; 1% – on local streets where average length of such congestions accounts for 0.3 km. The local streets were included into the survey results only when the cause of traffic congestion locates on that street.

Finding of traffic congestion cause was achieved by fixing the place of its beginning and measuring its total length.

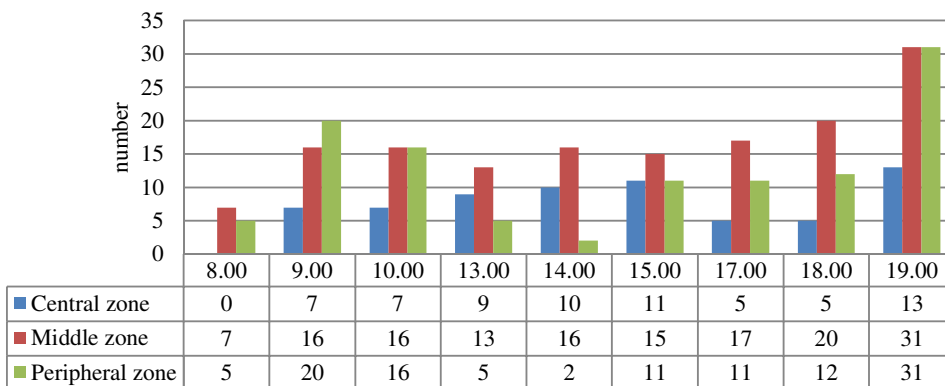


Fig. 6. The traffic congestion numbers in accordance with territorial zone of Kyiv city.

Factors causing traffic congestion were studied by analyzing various traffic situations. The main of such factors are the following: the traffic accident; road works; traffic signalization objects; traffic bottlenecks; pedestrian crossings; uncontrolled intersections. Analysis of such factors is represented in table 2 which contains information when traffic congestion length was more than 250 m. Otherwise the considered traffic congestion wasn't taken into account.

Table 2. Factors causing traffic congestions on arterial roads of Kyiv.

Time	Average traffic congestion length									
	Traffic accident		Road works		Traffic signalization objects		Traffic bottleneck		Pedestrian crossing	
	m	%	m	%	m	%	m	%	m	%
08.00	250	5.4	–	–	3800	81.7	600	12.9	–	–
09.00	5600	14.6	2050	5.3	27600	72.0	2850	7.4	250	0.7
10.00	4300	14.9	1550	5.4	18800	64.9	4300	14.9	–	–
13.00	1800	11.1	1400	8.6	12650	77.8	400	2.5	–	–
14.00	3900	16.5	2200	9.3	17600	74.3	–	0.0	–	–
15.00	2750	9.9	2000	7.2	22900	82.8	–	0.0	–	–
17.00	3200	15.5	600	2.9	15200	73.4	1700	8.2	–	–
18.00	3800	17.6	200	0.9	13250	61.3	4100	19.0	250	1.2
19.00	5100	9.1	600	1.1	41600	74.4	8200	14.7	400	0.7

The following are both the factors influencing a traffic congestion formation on arterial roads of Kyiv and measure of such factor influence on traffic congestion:

- pedestrian crossings. It was analyzed both signaled and uncontrolled pedestrian crossings which cause or complicate current traffic congestion situation. Such factor influenced only from 08.00 to 09.00 o'clock and in evening from 17.00 to 19.00 o'clock. In general relation of average traffic congestion length caused by pedestrian crossings to average traffic congestion length for the whole city accounts for 0.4% only;
- road works. It was analyzed all traffic congestions caused by any type of works that were performing within the street area and in such manner complicated traffic conditions for both pedestrians and vehicles. Such factor influenced from 09.00 to 15.00 o'clock mainly. In evening such type influence was insignificant within 1%. In general relation of average traffic congestion length caused by road works to average traffic congestion length for the whole city accounts for 4.5%;
- traffic bottleneck. Such category included entry and exit of roads, bridges, overhead road, the bridges and overhead roads themselves, places of passenger transport stops, narrowing of roadways or bad road conditions. As it follows from table 3, the traffic congestions caused by such factor are absent only in dinner time. The corresponding relation for traffic bottleneck accounts for 9.3%;
- traffic accidents have great influence on formation of traffic congestion on street network of Kyiv. The corresponding relation for traffic accidents accounts for 12.9%;
- traffic signalization objects. Such objects don't correspond mainly to the current intensity of traffic and usually represent the so-called problem places. The problem places require either the more effective traffic organization measures to apply or proper reconstruction and reorganization of corresponding road intersection. Relation of average traffic congestion length caused by traffic signalization to average traffic congestion length for the whole city accounts for 72.9%.

Weather conditions, as one of significant factors influencing the formation and growing of traffic congestions, are discussed separately. Influence of weather conditions on formation of traffic congestion was analyzed by comparing the number and length of traffic congestions at good and bad weather. It should be noted that under bad weather conditions the length of traffic congestions were growing: under rainy weather it increased by 20% and under

snowfall, – up to 45%. The number of traffic congestion places increased by 10% on average. This is because that bad weather conditions cause the growing number of traffic accidents which contribute to traffic delays and traffic congestion increase as well.

After determination of traffic congestion causes on arterial roads of Kyiv, it's necessary to analyze also those characteristic elements of street network where traffic congestions occur mainly. The bridges, overpasses, signal-controlled junctions, circular motion intersections and road stages were used as such characteristic elements (Table 3).

Table 3. The average traffic congestion length on certain elements of Kyiv street network.

Time	Average length of traffic congestions									
	Bridge		Overpass, and		Signal-controlled junction		Circular motion intersection		Road stage	
	m	%	m	%	m	%	m	%	m	%
08.00	1700	36.6	800	17.2	1850	39.8	300	6.5	–	–
09.00	6100	15.9	4450	11.6	25050	65.3	500	1.3	2250	5.9
10.00	4850	16.8	3800	13.1	18000	62.2	250	0.9	2050	7.1
13.00	300	1.8	250	1.5	14800	91.1	–	–	900	5.5
14.00	300	1.3	–	–	19500	82.3	–	–	3900	16.5
15.00	1000	3.6	–	–	22900	82.8	1100	4.0	2650	9.6
17.00	2600	12.6	2200	10.6	15300	73.9	600	2.9	–	–
18.00	4600	21.3	3900	18.1	10800	50.0	1600	7.4	700	3.2
19.00	8500	15.2	7500	13.4	35600	63.7	2900	5.2	1400	2.5

It should be noted that average traffic congestion length on various elements of Kyiv street network is distributed in following way: on bridges it equals 3.3 km, on overpasses, – 2.5 km, on signal-controlled junctions, – 18.2 km, on circular motion intersections, – 0.8 km and on road stages, – 1.5 km.

The traffic congestions on arterial roads of Kyiv depending on the day of week were observed in following sequence: the longest traffic congestions were recorded on Thursday while the shortest ones were recorded on Wednesday and accounted for 66% from total length of traffic congestions on Thursday. On Friday evening the length of traffic congestions becomes growing from 14 o'clock and from 16 to 19 o'clock it has been approximately on the same level without significant changes. For better understanding of such situation the average length of traffic congestion, like in surveys described above, were determined for every day of a week (Fig. 7). The distribution of traffic congestion length in percentage is represented on Fig. 8.

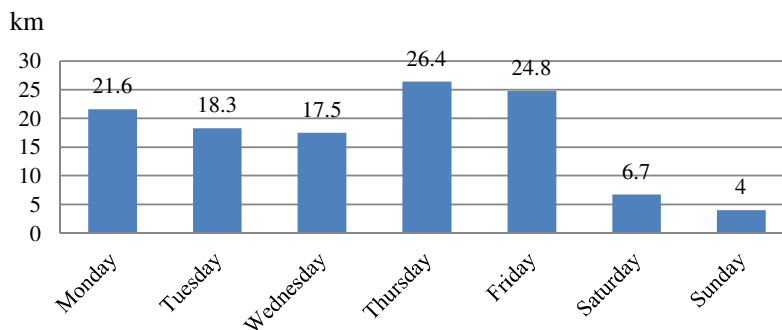


Fig. 7. The average length of traffic congestions (km) on streets of Kyiv by the days of a week.

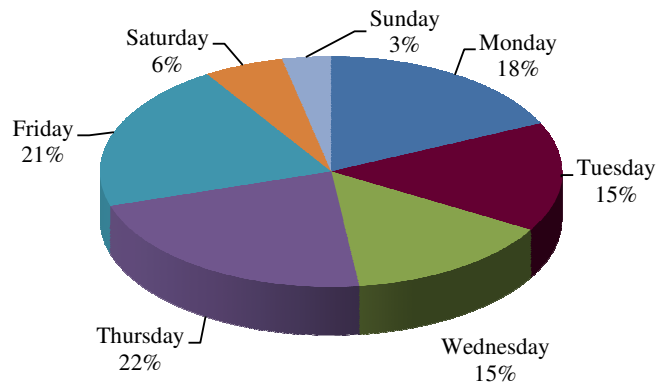


Fig. 8. Distribution of traffic congestion length in percentage by the days of a week.

In working hours of workdays it has been observed the sharp increase of vehicles number on streets of Kyiv: in morning from 08.30 to 09.30 and in the evening from 18.00 to 19.00 o'clock. It should be noted that traffic density in the evening time is in 1.5 times greater than in a morning time.

3. Conclusions

Analyzing the peculiarity of traffic congestion formation of street network of Kyiv it should be paid special attention to the fact that unpredictable traffic congestions caused by traffic accidents or road works account for only 17.4%, while the permanent traffic congestions occurred every day account for 82.6% of total number of traffic congestions.

On the April 2016, there are 12 most problem areas in Kyiv where traffic congestions occur during every working day. Such places require immediate reconstruction and engineering re-equipment.

The surveys performed enable to state that traffic congestions can't be eliminated by means of administrative sanctions or traffic management measures only when width of roadway is insufficient for current traffic density. Therefore only required level of transport infrastructure development enables to enhance the transport problem in cities.

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