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Identification of local attraction points of the traffic flow and methods of increasing the throughput capacity of Lokomotiv street in Tashkent

B. Rakhmat[1][a], R. Malikov[1][b]
[1]Tashkent State Transport University, Tashkent, Uzbekistan

Abstract: The article examines the formation of the traffic flow, the traffic volume and the throughput capacity of Lokomotiv street in Tashkent. A comprehensive analysis is presented of the main factors contributing to congestion, including the railway crossing, the T-shaped intersection, the technical condition of the pavement, the public transport stop and the irregular stopping and parking of vehicles. On the basis of field observations the hourly traffic volume and the composition of the traffic flow were determined. The design throughput capacity of the street was found to be 4840 veh/h, while the mean traffic volume calculated from the observations amounts to 1059.75 veh/h, which corresponds to a load factor of 0.219. The results show that, despite the sufficient overall capacity of the street, the breaking of the continuity of the traffic flow at individual local sections is one of the principal causes of congestion. The part of Lokomotiv street crossing the railway, where the number of traffic lanes is reduced from two to one, was identified as a local attraction point, i.e. a bottleneck. Taking into account the closure of the barriers for 10–15 min in every hour, the capacity of this cross-section is only 908–1008 veh/h and the degree of loading there reaches 0.58–0.64; during one closure period the queue reaches 680–1015 m, which is 1.9–2.9 times the length of the section under study, and takes 9–14 min to dissipate. In order to eliminate the problem, proposals were developed for carrying the street under the railway in a tunnel, ensuring the continuity of the traffic lanes, introducing adaptive signal control, optimising the location of the public transport stop, restricting irregular parking and applying intelligent transport systems.

Keywords: traffic flow, congestion, road throughput capacity, traffic volume, local attraction point, railway crossing, traffic flow density, road infrastructure, intelligent transport system, road safety

1. Introduction

The rapid growth of traffic flows in large cities today has a serious effect on the stable operation of the street and road network. Together with the increase in the number of vehicles, the correspondence of the road infrastructure to the existing transport demand, the throughput capacity of intersections, the location of public transport stops, the organisation of parking and the efficiency of the traffic control systems become equally important.

Traffic congestion appears when the vehicle flow on a given road section exceeds the available throughput capacity; it manifests itself in a decrease of the movement speed, in the accumulation of vehicles and in the formation of queues, and it is accompanied by a growth of the accident rate [19]. In urban conditions, however, the occurrence of congestion does not always mean that the overall design capacity of the street has been reached. In a number of cases local restrictions arising on separate parts of a street have an adverse effect on the whole traffic flow. From this point of view, the influence of local restrictions and of the network topology has to be taken into account when the throughput capacity of transport networks is assessed [1].

In Tashkent the reduction of traffic congestion is regarded as a task of state policy: Resolution of the President of the Republic of Uzbekistan No. PQ-368 of 4 December 2025 defines the tasks of improving the management of the transport system of the city, developing the transport infrastructure and preventing congestion [2–5].

A section of Lokomotiv street in Tashkent with relatively complex traffic conditions was selected as the object of the study. Within approximately 350 m of this street there are a T-shaped intersection and a railway crossing, and these elements affect the continuity of the traffic flow. The aim of the article is to evaluate the traffic conditions on Lokomotiv street, to identify the local causes of congestion and to substantiate the engineering and organisational measures directed at increasing the throughput capacity of the street.

2. Research methodology

The study used field observation, the counting of vehicles by type, the determination of the traffic volume, the assessment of the design throughput capacity of the street and the calculation of the load factor. The observations were carried out on Wednesday, 25 March 2026, during the morning and the evening peak periods. The vehicles were grouped into passenger cars, public transport, trucks and two-wheeled vehicles [6, 11].

The traffic volume is determined by the expression

$$q = N / t \qquad (1)$$

where q is the traffic volume, veh/h; N is the number of vehicles that have passed the observation cross-section during the given time; t is the observation time, h.

The design throughput capacity of one traffic lane was determined from the empirical expression

$$p = 1000 \cdot V / L_d \qquad (2)$$

where V is the design speed of the vehicles, km/h; L_d is the dynamic envelope of a vehicle, m. For V = 50 km/h and L_d = 41.3 m this gives p = 1000 × 50 / 41.3 = 1210 veh/h.

Since Lokomotiv street consists of four traffic lanes, the total design capacity of the cross-section is

[a] https://orcid.org/0009-0008-1128-0649
[b] https://orcid.org/0009-0000-0028-577X

$$P = p \cdot n = 1210 \times 4 = 4840 \text{ veh/h} \quad (3)$$

where n is the number of traffic lanes.

The degree of loading of the street by the traffic flow is assessed by the load factor

$$Z = q / P \quad (4)$$

At the railway crossing the number of traffic lanes is reduced from two to one in each direction, and in addition the movement is interrupted while the barriers are closed. The capacity of this cross-section was therefore determined as

$$P_{bn} = p \cdot (1 - t_{cl}/60) \quad (5)$$

where t_{cl} is the total closure time of the crossing per hour, min; according to the data of the railway operator the crossing is closed for 10–15 min in every hour. The number of vehicles accumulating in front of the closed crossing and the length of the queue were estimated as

$$n_q = q_{dir} \cdot t_{cl}/60, \quad l_q = n_q \cdot l_v \quad (6)$$

where q_{dir} is the traffic volume in one direction, veh/h, and l_v = 7 m is the average space occupied by a stopped vehicle in a queue. The time required for the dissipation of the queue after the barriers are opened is $t_d = n_q/(p - q_{dir})$ [14, 18].

3. Results and discussion

3.1. Traffic volume and composition

The results of the hourly observations on Lokomotiv street are given in Table 1 and in Figure 1.

Table 1

Traffic volume and composition on Lokomotiv street

Observation period	Total	Passenger cars	Public transport	Trucks	Two-wheelers
08:05–09:00	1024	907	27	50	19
09:05–10:00	1161	1054	33	39	35
18:05–19:00	1074	984	29	41	20
19:05–20:00	980	874	25	51	30
Total	4239	3819	114	181	104

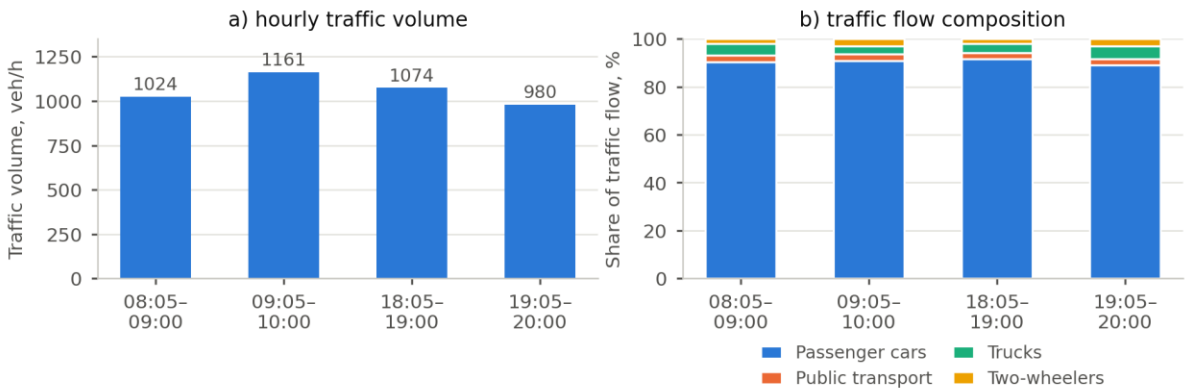

Fig. 1. Traffic volume (a) and composition of the traffic flow (b) on Lokomotiv street

The total number of vehicles recorded in the four observation intervals is N = 1024 + 1161 + 1074 + 980 = 4239 veh, which corresponds to a mean traffic volume of q = 1059.75 veh/h. The maximum value was recorded in the interval 09:05–10:00 and amounts to 1161 veh/h, and the minimum value, 980 veh/h, in the interval 19:05–20:00. During the morning period 08:05–10:00 a total of 2185 vehicles passed the observation cross-section.

Passenger cars form 90.5 % of the traffic flow, trucks 4.3 %, public transport 2.7 % and two-wheeled vehicles 2.5 %; the composition remains practically unchanged during all four intervals (Figure 1, b). Such a composition means that the flow is homogeneous in terms of dynamic characteristics, and consequently the losses of capacity are caused not by the vehicle mix but by the geometry of the street and by the organisation of the movement [9, 10].

3.2. Throughput capacity and load factor

The results of the capacity calculation are summarised in Table 2.

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Table 2

Calculation of the throughput capacity and of the load factor of Lokomotiv street

Parameter	Symbol	Value
Design speed	V	50 km/h
Dynamic envelope of a vehicle	L_d	41.3 m
Capacity of one lane	p	1210 veh/h
Number of lanes	n	4
Capacity of the cross-section	P	4840 veh/h
Mean observed traffic volume	q	1059.75 veh/h
Maximum observed traffic volume	q_{max}	1161 veh/h
Load factor at the mean volume	Z	0.219
Load factor at the maximum volume	Z_{max}	0.240

The load factor at the mean observed volume is $Z = 1059.75 / 4840 = 0.219$, and even at the maximum observed volume it does not exceed 0.240. Consequently, the design throughput capacity of the whole cross-section of the street is considerably higher than the observed traffic volume, and the street as a whole works at about one quarter of its capacity.

This result, however, does not lead to the conclusion that congestion cannot occur on Lokomotiv street. On the contrary, it shows that congestion has to be analysed not from the point of view of the overall capacity, but from the point of view of local capacity restrictions.

3.3. Local attraction points of the traffic flow

Lokomotiv street is approximately 350 m long and has four traffic lanes for movement in opposite directions. In the approach to the railway crossing, however, the effective width of the carriageway decreases sharply and the number of lanes is reduced from two to one in each direction. This section was identified as a local “attraction point”, i.e. a bottleneck of the street, at which the continuity of the traffic flow is broken. The results of its calculation are given in Table 3.

Table 3

Calculation of the capacity of the bottleneck at the railway crossing

Parameter	Symbol	Value
Total closure time of the crossing per hour	t_{cl}	10–15 min
Capacity of the single-lane cross-section at the crossing	P_{bn}	908–1008 veh/h
Traffic volume in one direction at the maximum hour	q_{dir}	580 veh/h
Degree of loading at the crossing	Z_{bn}	0.58–0.64
Vehicles accumulated while the barriers are closed	n_q	97–145 veh
Length of the queue	l_q	680–1015 m
Time of queue dissipation	t_d	9–14 min
Length of the section under study	L_s	350 m

With p = 1210 veh/h and a closure time of 10–15 min/h the capacity of the single-lane cross-section at the crossing is 908–1008 veh/h, which is 4.8–5.3 times lower than the design capacity of the whole cross-section of the street. The traffic volume in one direction during the maximum observed hour is 580 veh/h, so that the degree of loading at the crossing reaches 0.58–0.64 against 0.24 for the street as a whole, that is, 2.4–2.7 times higher.

The decisive factor, however, is not the hourly balance but the discontinuity of the service. While the barriers are closed, 97–145 vehicles accumulate in one direction; at a space of 7 m per vehicle the queue reaches 680–1015 m, which is 1.9–2.9 times the length of the section under study. The queue therefore extends beyond the T-shaped intersection and blocks it, and after the barriers are opened it takes 9–14 min to dissipate; a standing queue at a level crossing is at the same time one of the principal risk factors of accidents at such crossings [16]. Since the total closure time is 10–15 min in every hour, the crossing remains in the state of queue formation or queue dissipation during practically the whole peak period. This explains why congestion is systematically observed on Lokomotiv street although the load factor of the street as a whole is only 0.22, and it corresponds to the known result that the capacity of an urban network is governed by its local restrictions rather than by the sum of the capacities of its links [1, 15].

The observations showed that several factors interact in the formation of congestion on Lokomotiv street: the narrowing of the carriageway at the railway crossing, the geometry of the T-shaped intersection, the unsatisfactory technical condition of the pavement, the location of the public transport stop close to the intersection, and the irregular stopping and parking of vehicles along the carriageway. Each of these factors reduces the locally available capacity, while the design capacity of the street as a whole remains unused [7, 8].

3.4. Proposed measures

– construction of a tunnel carrying Lokomotiv street under the railway, which removes the principal local restriction and ensures the continuity of the traffic lanes;

– adaptive control of the traffic signals at the T-shaped intersection in accordance with the actual traffic volume [13, 17];

– renewal of the traffic signs and of the road markings [12] and extension of video surveillance and automatic enforcement systems;

– relocation of the public transport stop away from the intersection and arrangement of an off-street stopping bay;

– restriction of irregular parking and the organisation of designated parking areas.

4. Conclusion

1. The field observations on Lokomotiv street in Tashkent gave a mean traffic volume of 1059.75 veh/h with a maximum of 1161 veh/h in the interval 09:05–10:00. Passenger cars form 90.5 % of the flow, so that the flow is homogeneous in terms of dynamic characteristics.

2. The design throughput capacity of the four-lane cross-section is 4840 veh/h, and the load factor does not exceed 0.240 even at the maximum observed volume. The capacity of the street as a whole is therefore not exhausted.

3. Notwithstanding the sufficient overall capacity, the continuity of the traffic flow is broken at individual local sections, and this is one of the principal causes of congestion. The part of Lokomotiv street crossing the railway, where the number of traffic lanes is reduced from two to one, was identified as a local attraction point, i.e. a bottleneck of the street.

4. Taking into account the closure of the barriers for 10–15 min in every hour, the capacity of the single-lane cross-section at the crossing is 908–1008 veh/h, which is 4.8–5.3 times lower than the design capacity of the street, and the degree of loading there reaches 0.58–0.64. During one closure period 97–145 vehicles accumulate in one direction, the queue reaches 680–1015 m — 1.9–2.9 times the length of the section under study — and its dissipation takes 9–14 min. The crossing therefore remains in the state of queue formation or dissipation during practically the whole peak period, which explains the systematic congestion in spite of the low load factor of the street as a whole.

5. In order to eliminate the problem it is proposed to carry the street under the railway in a tunnel, to ensure the continuity of the traffic lanes, to introduce adaptive signal control, to optimise the location of the public transport stop, to restrict irregular parking and to apply intelligent transport systems. The reduction of congestion in Tashkent requires not a single measure but an approach based on the joint management of the road infrastructure, the traffic flow, digital control, public transport and the parking system.

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Information about the author

Bakhtiyor Rakhmat	Tashkent State Transport University, Department of Traffic Organisation, acting associate professor E-mail: raxmatbaxtiyor66@gmail.com Tel.: +998 97 429 93 11 https://orcid.org/0009-0008-1128-0649
Ravshanbek Malikov	Tashkent State Transport University, Department of Traffic Organisation, acting associate professor E-mail: ravshanbek22121978@gmail.com Tel.: +998 99 468 53 20 https://orcid.org/0009-0000-0028-577X

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