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Analysis of the state of the road infrastructure at the intersection of the Dombirobod Small Ring Road and Chilonzor street in Tashkent

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Abstract: The article analyses the state of the road infrastructure and of the traffic flows at the intersection of the Dombirobod Small Ring Road and Chilonzor street, one of the busiest transport nodes of Tashkent. A field inventory of the traffic control devices and a field count of the traffic flow on all four approaches were carried out, separately for the entering and the leaving vehicles, over the morning period 06:30–09:30 in 30-minute intervals and over the evening peak hour. The inventory showed that the intersection is provided with a traffic signal to 70 % and with direction-of-travel signs to 50 % of the required extent, while the priority sign, the pedestrian crossing sign and the speed-limit sign are completely absent. During the morning peak hour 08:00–09:00 the intersection is entered by 5121 veh/h and during the evening hour 17:00–18:00 by 6000 veh/h, so that the design peak occurs in the evening and exceeds the morning one by 17.2 %; the approaches of the Small Ring Road account for 65.0 % and 57.0 % of these volumes respectively. On this basis a two-phase signal control scheme was calculated by the Webster formula: with a saturation flow of 5400 veh/h per three-lane approach and a lost time of 18 s the cycle length is 85 s, rounded up to 88 s, with effective green times of 44 s and 26 s, which gives a degree of saturation of 0.78 on both critical approaches. The installation of the missing traffic signs and the renewal of the road markings are proposed in addition.

Keywords: traffic flow, intersection, traffic organisation, throughput capacity, congestion, traffic control devices, signal control, road safety

1. Introduction

The principles of traffic organisation are aimed at directing the traffic flow correctly, dividing it into speed groups where necessary, setting rational speeds for each road element, and providing drivers with timely information about the route and the road conditions. Within this set of tasks, the management of the traffic flow remains the most pressing problem of road traffic safety [1–3].

The transport mobility of the urban population is growing every year, which in turn creates a number of problems in providing transport services to the population. Changes in the irregularity coefficient of the passenger flow have an adverse effect on the efficiency of public transport operation, while the random character of the variation of passenger-flow parameters — the main criterion for organising urban public transport — further complicates the rational organisation of this process.

The magnitude of the traffic flow, regular congestion during the peak hours, the low throughput capacity of streets and the need to ensure traffic safety are among the problems that engineers have to solve; the capacity of an urban network is governed not by the sum of the capacities of its links but by its most loaded nodes [16]. In Tashkent, the rapid growth of the population and of the vehicle fleet increases the demand for transport infrastructure and, at the same time, creates problems of safety at intersections.

The intersection of the Dombirobod Small Ring Road and Chilonzor street is one of the busiest and most complex transport nodes of the city: it links different parts of Tashkent, including the central districts, large shopping complexes, government institutions and residential areas. Because of the excessive density of traffic flows, the insufficient number of pedestrian crossings and the outdated road structures, serious congestion is observed here during the daytime. Congestion at an intersection is directly related to the accident rate: the frequency of accidents increases with the traffic volume, and this relationship is particularly pronounced at signalised intersections [14, 15]. The improvement of the safety arrangements at this node is therefore an urgent practical task [4, 5, 7].

The aim of the present work is to analyse the current state of the road infrastructure and of the traffic flows at this intersection, to identify the principal risk factors and to substantiate engineering measures for their elimination. The results may be applied not only to the intersection under study, but also to other heavily loaded intersections of the city.

2. Research methodology

The study combines a field inventory of the traffic control devices with a field count of the traffic flow at the intersection.

The inventory covered the traffic signs, road markings and signal equipment installed at the intersection. For every type of device the provision level was determined as the ratio of the number of devices actually installed to the number required by the traffic organisation scheme [8, 9], expressed as a percentage. The values obtained are independent of one another and characterise each type of device separately.

The traffic count was carried out on Wednesday, 25 March 2026, on all four approaches of the intersection separately for the vehicles entering and for the vehicles leaving it. The morning period 06:30–09:30 was recorded in six 30-minute intervals, and the evening peak hour 17:00–

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18:00 was recorded as a single interval. For every approach the total morning volume, the evening hourly volume and the ratio between them were determined. The peak-hour volume was obtained as the sum of the two consecutive 30-minute intervals with the highest counts. Each approach of the intersection has three traffic lanes.

2.1. Assessment of the capacity and of the signal timing

The capacity of an approach controlled by a traffic signal was determined as

$$c = S \cdot g / C \quad (1)$$

where S is the saturation flow of the approach, veh/h; g is the effective green time of the corresponding phase, s; C is the cycle length, s. The saturation flow was taken as 1800 veh/h per lane, so that for a three-lane approach S = 5400 veh/h [12].

The cycle length was determined by the Webster formula [11]:

$$C_0 = (1.5L + 5) / (1 - Y) \quad (2)$$

where L is the total lost time per cycle, s; Y is the sum of the flow ratios $y = q/S$ of the critical approaches of the phases. The effective green time of a phase is distributed in proportion to the flow ratios:

$$g_i = (C - L) \cdot y_i / Y \quad (3)$$

and the degree of saturation of an approach is $X = q/c$. The admissible value of X for an urban signalised intersection is taken as 0.85 [12, 13].

The road infrastructure of the intersection was assessed with respect to four components: the pavement, the width of the carriageway and the layout of the lanes, the traffic signs and the signal system, and the auxiliary road facilities. The pavement of the intersection is made of high-quality asphalt concrete; its thickness, composition and the durability of the materials are among the factors that determine traffic safety and the service life of the road. The condition of the pavement has to be inspected regularly, since it directly affects the speed and the stability of vehicle movement [3, 6].

3. Results and discussion

3.1. Provision of traffic control devices

The results of the inventory of the traffic control devices are given in Table 1 and in Figure 1.

Table 1

Provision of traffic control devices at the Dombirobod – Chilonzor intersection

Traffic control device	Provision, %	Remark
Priority (main road) sign	0	Intersection priority is not defined
No-stopping sign	30	Partly present, but insufficient
Pedestrian crossing sign	0	Creates a hazard for pedestrians
Direction-of-travel sign	50	Present for the main flow only
Speed-limit sign	0	No speed-limit sign observed
Traffic signal	70	A signal controlling the movement is present

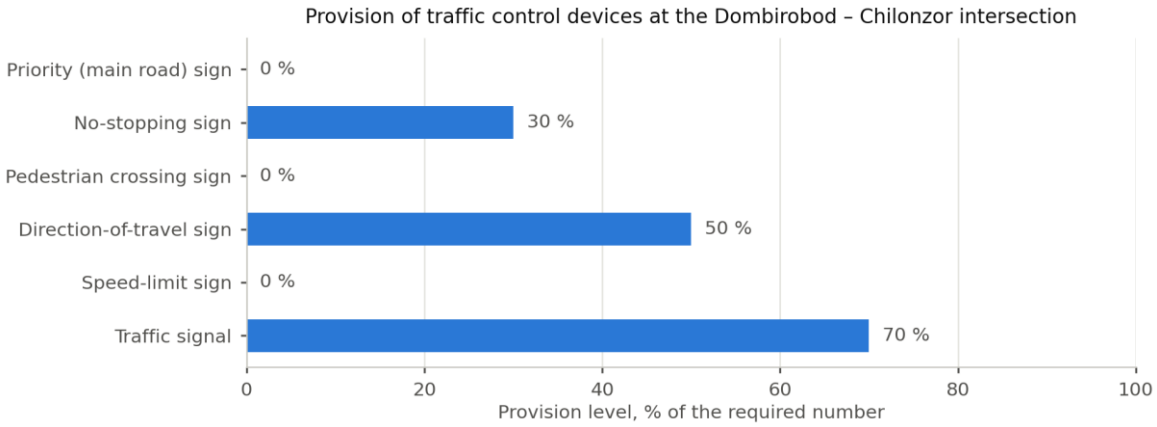

Fig. 1. Provision of traffic control devices at the intersection (the values are independent of one another and are not parts of a whole)

Although a traffic signal is installed at the intersection, the other essential devices — the priority sign, the pedestrian crossing sign and the speed-limit sign — are completely absent, and the no-stopping sign is provided only to 30 % of the required extent. The absence of a priority sign means that the precedence at the intersection is not formally defined, and the absence of pedestrian crossing signs creates a direct hazard for pedestrians. This combination makes the regulation of both vehicle and pedestrian movement difficult and is one of the sources of conflict situations at the intersection.

3.2. Traffic volumes at the approaches

The results of the traffic count are given in Table 2, and the dynamics of the entering flows during the morning period are shown in Figure 2.

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Table 2

Number of vehicles at the approaches of the intersection during the periods of the highest congestion and accident rate

Approach	06:30–07:00	07:00–07:30	07:30–08:00	08:00–08:30	08:30–09:00	09:00–09:30	Total	17:00–18:00	Ratio
Vehicles leaving the intersection									
Small Ring Road (towards Chilonzor metro)	295	579	759	793	1017	762	4205	2393	1.76
Dombirobod street	159	303	387	417	440	294	2000	1102	1.81
Chilonzor street	245	354	426	489	521	389	2424	777	3.12
Small Ring Road (towards Yuzhny station)	178	343	537	667	777	475	2977	1728	1.72
Vehicles entering the intersection									
Small Ring Road (from Chilonzor metro)	349	648	807	976	1045	677	4502	2113	2.13
Dombirobod street	204	335	387	439	570	398	2333	1328	1.76
Chilonzor street	121	242	301	376	410	417	1867	1252	1.49
Small Ring Road (from Yuzhny station)	203	354	614	575	730	428	2904	1307	2.22

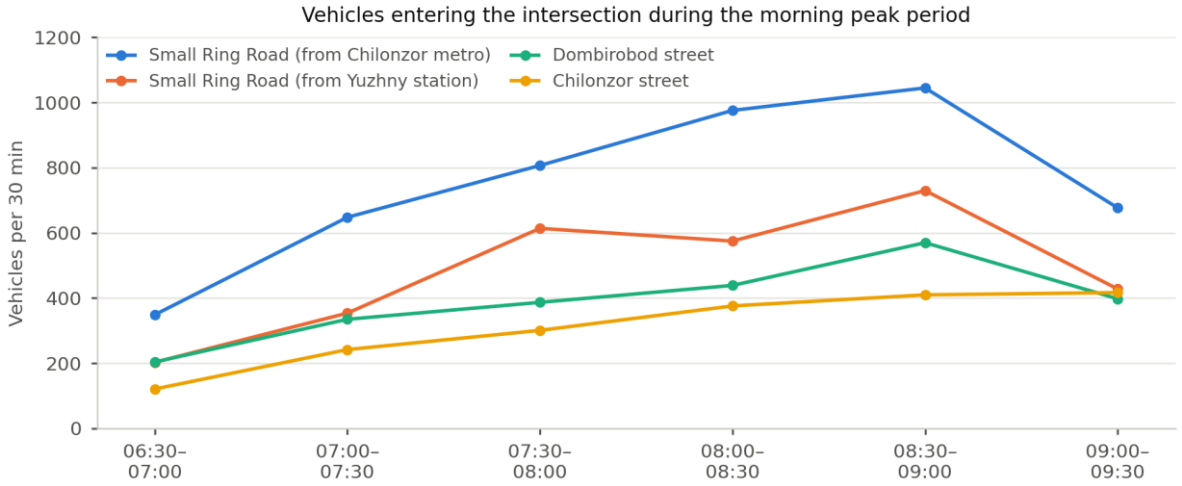

Fig. 2. Vehicles entering the intersection during the morning period

The Small Ring Road carries the main share of the traffic: over the morning period 4502 vehicles entered the intersection from the Chilonzor metro side and 2904 from the Yuzhny station side, that is, 61.0 % of all entering vehicles.

The last column of Table 2 gives the ratio of the three-hour morning volume to the volume of the evening hour. A value of 3.0 would mean that the average morning hourly rate equals the evening one; on seven of the eight approaches the ratio is below 3.0, that is, the evening hour is busier than an average morning hour. The only exception is the flow leaving towards Chilonzor street (3.12).

During the morning period all four entering flows reach their maximum in the interval 08:30–09:00 (Figure 2); only on the Chilonzor street approach does the flow continue to grow until 09:00–09:30. The volumes of the two peak hours

— the morning peak hour 08:00–09:00, obtained as the sum of the two highest consecutive 30-minute intervals, and the evening hour 17:00–18:00 — are compared in Table 3.

Table 3

Traffic volumes at the approaches during the morning and the evening peak hours, veh/h

Approach	Morning peak hour 08:00–09:00, entering	Morning peak hour 08:00–09:00, leaving	Evening hour 17:00–18:00, entering	Evening hour 17:00–18:00, leaving
Small Ring Road, Chilonzor metro side	2021	1810	2113	2393
Small Ring Road, Yuzhny station side	1305	1444	1307	1728
Dombirobod street	1009	857	1328	1102
Chilonzor street	786	1010	1252	777
Total	5121	5121	6000	6000

During the morning peak hour 5121 veh/h enter and the same number leaves the intersection; during the evening hour these values reach 6000 veh/h. The equality of the entering and the leaving volumes in both hours confirms the internal consistency of the counts. The design peak of the intersection therefore occurs in the evening and exceeds the morning peak by 17.2 %, and it is this value that has to be taken as the basis for the design of the signal programme.

The distribution of the volume between the approaches also changes between the two peaks. In the morning peak hour the Small Ring Road approaches account for 3326 veh/h, or 65.0 % of the entering volume, whereas in the evening hour their share falls to 57.0 % (3420 veh/h) and the combined share of the Dombirobod and Chilonzor street approaches rises from 35.0 % to 43.0 %. Since the flows of the Small Ring Road are crossed by the left-turning movements from Chilonzor street, the number of conflict points at the intersection increases considerably, and the throughput capacity available for the Small Ring Road direction proves to be insufficient during both peak hours [8, 10].

3.3. Capacity of the intersection and the signal programme

The calculation was performed for the design (evening) peak hour. In the proposed two-phase scheme the first phase serves the Small Ring Road and the second one the Dombirobod and Chilonzor street approaches, so that the critical flows are 2113 and 1252 veh/h respectively (Table 3). With S = 5400 veh/h this gives the flow ratios y_1 = 0.391 and y_2 = 0.232 and their sum Y = 0.623.

With a lost time of 9 s per phase (L = 18 s) the Webster formula gives $C_0 = (1.5 \cdot 18 + 5)/(1 - 0.623) = 85$ s. The cycle was rounded up to C = 88 s in order to provide the minimum pedestrian green time on the wide approaches of the Small Ring Road. The effective green time $C - L$ = 70 s, distributed in proportion to the flow ratios, gives g_1 = 44 s and g_2 = 26 s. The results are summarised in Table 4.

Table 4

Calculation of the capacity of the intersection and of the two-phase signal programme

Parameter	Phase 1 — Small Ring Road	Phase 2 — Dombirobod and Chilonzor streets
Critical flow q, veh/h	2113	1252
Saturation flow S, veh/h	5400	5400
Flow ratio $y = q/S$	0.391	0.232
Effective green time g, s	44	26
Capacity $c = S \cdot g/C$, veh/h	2700	1595
Degree of saturation $X = q/c$	0.78	0.78

With these settings the capacity of the Small Ring Road approach is 2700 veh/h and its degree of saturation 0.78; for the second phase the corresponding values are 1595 veh/h and 0.78. Both values are below the admissible limit of 0.85, so that the proposed programme provides the required

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capacity during the design peak hour, although it leaves a reserve of only about 20 %.

3.4. Proposed traffic organisation measures

In addition to the signal programme, a set of measures for improving the technical means of traffic organisation is proposed: the installation of the missing priority, pedestrian crossing and speed-limit signs, the renewal of the road markings and the installation of additional signal heads [9, 10, 13]. The implementation of these measures reduces the number of conflict points and brings the provision of traffic control devices into correspondence with the traffic organisation scheme.

4. Conclusion

The inventory of the traffic control devices showed that the intersection of the Dombirobod Small Ring Road and Chilonzor street is provided with a traffic signal to 70 % and with direction-of-travel signs to 50 % of the required extent, whereas the priority sign, the pedestrian crossing sign and the speed-limit sign are completely absent. The precedence at the intersection is therefore not formally defined.

2. The intersection has two peaks: during the morning peak hour 08:00–09:00 it is entered by 5121 veh/h and during the evening hour 17:00–18:00 by 6000 veh/h, the evening peak exceeding the morning one by 17.2 %. The approaches of the Small Ring Road account for 65.0 % of the entering volume in the morning and for 57.0 % in the evening. The volume arriving along the Small Ring Road from the Chilonzor metro side exceeds the throughput capacity available for this direction.

3. On seven of the eight approaches the average morning hourly volume is lower than the volume of the evening hour, so that the signal programme has to be designed for the evening peak. The largest difference is observed on the Chilonzor street approach, where the evening entering volume exceeds the average morning one by a factor of 2.01.

4. The Webster calculation performed for the design peak hour with a saturation flow of 5400 veh/h per three-lane approach and a lost time of 18 s per cycle gives a cycle length of 85 s, which was rounded up to 88 s, and effective green times of 44 s and 26 s for the two phases. With this programme the degree of saturation of both critical approaches is 0.78, which is below the admissible limit of 0.85 but leaves a reserve of only about 20 %.

5. Together with the signal programme it is proposed to install the missing priority, pedestrian crossing and speed-limit signs and to renew the road markings. These measures reduce the number of conflict points at the intersection and can be applied to other heavily loaded intersections of the city.

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