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Choice of the rational regimes of traffic light control for traffic and pedestrian flows

Key words: pedestrian flow, traffic flow, traffic intensity, speed of movement, volume-capacity ratio, traffic light control, traffic simulation

Introduction

An important direction for transport problems solving is the formation of cities' road networks with increased capacity, improvement, and provision of conditions for public transport movement (separate lanes allocation and provision the priority in movement). It is quite hard to take into account simultaneously these factors, especially for cities with a historical road network. It is possible to solve this problem with the help of the implementation of modern technologies, automated traffic control systems, in particular, to improve the traffic light control system at the intersections (pedestrian crosswalks). Such management should satisfy the requests of road users, based on objective functions – safety and speed of movement.

Traffic light control systems at the intersections in existing conditions have limited time parameters by regulatory documents, although they operate both in adaptive (flexible) and fixed-time regimes. Such systems mainly consider the needs of traffic flows, giving minimal duration for serving pedestrian flows. The existing approach to the balancing of traffic light duration does not always take into account the peculiarities of the pedestrian movement who try to cross the roadway in every convenient moment in time, even in conditions of risk. As result, traffic safety at grade level pedestrian crosswalks reduces (deteriorates).

Analysis of literature and problem statement

During the design of the traffic light cycle duration, to determine the rational control regime, minimal time, which provides crossing the roadway by pedes-

trians, takes into account. In recommendations, the methodology for determining the duration of crossing the roadway by pedestrians is given. The majority of these methodologies are based on assumptions about the average speed of pedestrian movement. That way, in recommendations of the Transportation Research Board (2000), the speed of pedestrian movement is considered $1.2 \text{ m}\cdot\text{s}^{-1}$; in the manual of Japan Society of Traffic Engineers (2006), the speed is $1.0 \text{ m}\cdot\text{s}^{-1}$; in the studies of Ukrainian researchers – $1.3\text{--}1.4 \text{ m}\cdot\text{s}^{-1}$.

For the investigation of the speed of pedestrian flows at the grade crosswalks, several techniques are developed, but the majority of them do not consider the impact of counterflow. Various authors developed the model of the duration of crossing the roadway by pedestrians, considering the length and width of the crosswalk, and also the density of conflicting flow (Alhajyaseen, Nakamura & Catbagan, 2008; Alhajyaseen & Nakamura, 2010; Iryo-Asano & Alhajyaseen, 2017; Wang, Zhao, Cao, Lu & Chen, 2017). During pedestrian flows simulation, the method was used which considers pedestrian delays which had formed in result of counterflow impact (the group of pedestrians with a maximal density which had formed at pedestrian crosswalks). The investigation showed that with the intensity approximately equal at each side of the crosswalk (dense flow), pedestrian speed decreases to one third with the comparison to the flow, which moves in one direction. As result, the conclusion was that the impact of conflicting flows is significant and should be reviewed during the design of traffic light control systems to determine

the optimal time needed for crossing the roadway by the groups of pedestrians.

In the study by Alhajyaseen and Nakamura (2012), the method of the determination of traffic light cycle duration taking into account the length of the pedestrian crosswalk, which allows minimizing traffic and pedestrian delays, is given. This method considers the density, intensity, speed of traffic and pedestrian flows, and geometric parameters of the roadway. During the calculation of the traffic light cycle duration, two limitations are considered: optimal duration of permissive signal for traffic flow and minimal duration for the pedestrian.

The main restrictions, which are used during the calculation of traffic light system, are the minimal duration of permissive signal for traffic flow and maximal duration of restrictive signal for pedestrian flow (Transportation Research Board [TRB], 2000; Vrubel, 2003; Levashev, Mykhailov & Holovnykh, 2007; Vasylieva, 2007; Polishchuk & Bakulich, 2012). An experience of the investigation of pedestrian behavior at signalized intersections shows that the duration of patient waiting of green signal by them can be within 30–90 s (Vrubel, 2003; Xiong, Xiong, Deng & Wang, 2014). With such values of restrictive signal, the number of violators is no more 15% (Gong, Xiao & Xu, 2019; Ma, Lu & Zhang, 2020). By the duration of the patient waiting for a green traffic light signal by pedestrians means maximal time, which the pedestrian is ready to spend to wait for such signal.

Many researchers establish the values of limits of traffic light cycle duration by empirical dependencies. Vrubel (2003) investigated that the cycle du-

ration should be no less than 70 s for two-phase control; no less than 90 s for three-phase control; no less than 110 s for four-phase control.

In recommendations by Polishchuk and Bakulich (2012), the limitations of minimal duration of the traffic light cycle are given (no less than 25 s). It is explained by the fact that with a short cycle duration, delays in traffic flow increases and capacity decreases.

Analysis of literature data established many factors: minimal time, needed to pedestrians for crossing the roadway, the duration of the permissive and restrictive signal of the traffic light, intensity, density, speed of traffic and pedestrian flows, geometric parameters of intersection – crosswalk (Zhyvohliadov, 2012). However, such factors are not taken into account as a pedestrian discipline, location of the crosswalk relatively functional zone of the city, the designed purpose of pedestrian movement, climate conditions, and determination the distance between pedestrian crosswalks. Given factors, determine the behavior of pedestrians in compliance with the traffic rules.

Based on the above, the problem of choosing the rational regimes of traffic light control for traffic and pedestrian flows remains topical.

Aim and tasks of the research

The aim of the study is an investigation of traffic and pedestrian flows for choosing the rational regimes of traffic light control.

To achieve the goal, such tasks are formed to:

- reveal the regularities and methods of research of road users indicators;
- investigate road users indicators and pedestrian behavior at signalized intersections;
- choose rational regimes of traffic light control for traffic and pedestrian flows;
- justify the recommendations about the choice of rational regimes of traffic light control for signalized intersections of different types.

Research techniques

Experimental determination technique

To evaluate quantitatively the duration of patient waiting by pedestrians it is necessary to research the process of crossing the roadway by pedestrians. Obtained results will allow determining the factors, which have a direct impact on the time of pedestrians' patient waiting. But, it is necessary to consider such indicators as traffic intensity, density, and composition, traffic light control regime, roadway geometric parameters, district type where the intersection is located (residential, central, and suburb district of the city), climate conditions, etc.

To measure the duration of pedestrians' patient waiting, we used the method, which is based on the investigation of pedestrian behavior during crossing the roadway by them.

On the primary stage of the research conduction, we determined:

- geometric parameters of the roadway (crosswalk), and the duration of permissive and restriction signals of a traffic light;

- recorded the number of pedestrians who crossed the crosswalk in such sequence: recorded the number of persons who crossed the roadway while turning on the permissive signal of the traffic light; recorded the moment of the crossing of the last pedestrian on the permissive signal; recorded the number of pedestrians who crowded during the restrictive signal of a traffic light; recorded the number of pedestrians who crossed the roadway during the restrictive signal;
- while turning on the permissive signal of a traffic light for transport, we recorded the number of vehicles that cross the stop-line.

In the next stage, we determined the type of traffic light control (fixed-time or adaptive) and climate conditions.

In the final stage, we determined the speed, with which the pedestrians cross the roadway. To obtain this indicator (speed of pedestrians), we recorded the time which pedestrians spent crossing the roadway with the help of a stopwatch. The experiment was carried out no less than 20 times for different age categories of pedestrians (young, middle age, and old) on each of the investigated objects, and after we calculated the average speed of pedestrian flow.

It was established that the duration, necessary for pedestrians to cross the roadway depends on the length and width of the crosswalk, and pedestrian flow intensity.

Simulation modeling technique

To evaluate operation regimes of traffic and pedestrian flows, there are many foreign and domestic programs

and projects, within which the research, modeling, and analysis of cities' road network condition are carried out. Both powerful software package PTV Vissim and simple mathematical models can be distinguished.

To develop a transport model in PTV Vissim software, it is necessary to carry out such operations:

- to calibrate the map of research objects, build streets which approach the research objects, set the appropriate widths and the number of lanes;
- due to the results of field research, to create incoming traffic flows on every approach to the intersection (crosswalk), specify respectively their composition and allowed movement directions. Speed of vehicle movement is specified separately for every type, and restrictions on turns are set;
- as the movement of traffic and pedestrian flows is controlled by the traffic light signalization, it is necessary to create signal groups and specify the duration of permissive and restrictive signals for each phase;
- while crossing the traffic flows in one control phase, it is necessary to enter appropriate priorities for specific flows;
- to determine traffic flow delays (in s·vehicle⁻¹) and vehicle queue length (in m), it is necessary to set measuring points on each approach to the intersection (crosswalk).

At signalized intersections (crosswalks), it is necessary to carry out pedestrian flow simulation similarly to the traffic flow. For the proper operation of such model, it is necessary to set the incoming pedestrian flow and (for needs) pedestrian routes of movement.

The main parameters of pedestrian movement within at-grade crosswalks are intensity, density, and speed of pedestrian movement; the number of crosswalks; the presence of points of attraction near the investigated research object.

Research results

Pedestrian behavior model depending on the movement intensity and crosswalk length

Experimental measurements of traffic and pedestrian flow indicators were carried out on sections of road network of Lviv city. In the primary stage of this research, the range of objects was chosen – signalized intersections and crosswalks beyond intersections. Chosen objects differed by the width of the roadway on

approaches to the stop-line (from lane to three lanes on the direction), distance between adjacent stop-lines (about from 50 to 700 m) and signalized intersections – by the number of pedestrians (from 3 to 5). Intersections, where pedestrian behavior was investigated, were considered with fixed-time traffic light cycle. All investigated intersections were conditionally divided into three types relative to their location on the city territory: type I – near transport junctions; type II – central zone; type III – residential zone (Table 1).

Based on the goal, task, and method of experimental measurement, eight signalized intersections and pedestrian crosswalks of each type were chosen for its conduction. Taking into account the fact that indicators of traffic and pedestrian flows are characteristic for the change during the day, measurements were car-

TABLE 1. Types of signalized intersections and pedestrian flows relative to their location on the city territory

Intersection type	Location on the city territory	Peculiarities of pedestrian flow movement	Peculiarities of traffic flow movement	Presence of flows generation center
I	near transport junctions	permanent intensive in peak periods; oriented in the direction to and from generation centers	large heterogeneity of traffic flow (up to 70% of cars); significant share of urban public transport, maneuverability at the car parking	trade establishments, bus stations, and railway stations
II	central zone	permanent intensive during daylight	significant homogeneity of traffic flow (up to 95% of cars)	precise generation center is absent, distribution of pedestrian flows by the territory is steady
III	residential zone	changeable, evenly directed in all zone	share of cars is 80–85%, urban public transport – up to 10%, freight transport almost absent	stopping points of urban public transport

ried out for peak (morning and evening) and inter-peak periods. For each period, appropriate indicators were fixed during 50 traffic light cycles. It is important that during these measurements recordings from surveillance cameras from the Center of traffic management of Lviv city were used, which allowed fixating traffic indicators and pedestrian behavior (number of violations) simultaneously with involvement of small number of researchers. We consider this as an advantage of this method.

The operation of signalized intersections and crosswalks was analyzed to investigate pedestrian behavior taking into account their intensity and crosswalk width. On such intersections, the duration of restrictive signal for pedestrians

changed from 26 to 115 s. Results of this research are processed in the MS Office Excel software. Experimental dependencies of the number of violations of the traffic rules by pedestrians, which cross the roadway in risk conditions from traffic flow intensity, expressed through the volume-capacity ratio, are obtained (Fig. 1). Volume-capacity ratio (z) was determined as interrelation of traffic intensity (N) to capacity (P): $z = N / P$. Maximum permissible capacity of one lane on intersections of type I is 750–850 pcu·h⁻¹; for type II – 800–900 pcu·h⁻¹; for type III – 800–1,000 pcu·h⁻¹. Traffic intensity determines by results of experimental measurements. Here, it is not indicated how the number of violations of traffic rules by pedestrians will

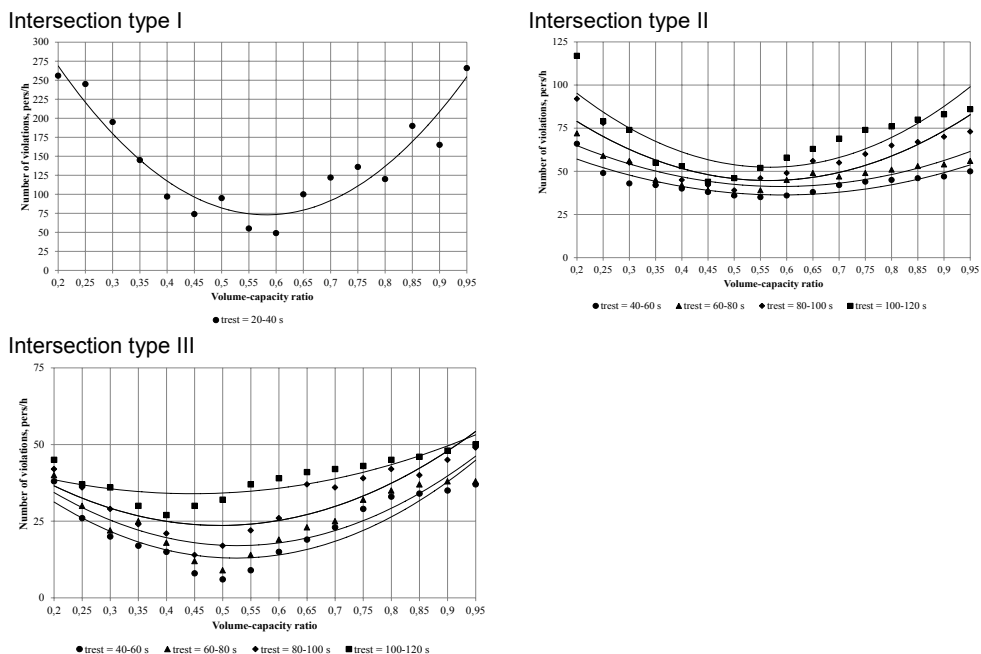


FIGURE 1. Experimental and approximated dependencies of the number of violations the traffic rules by pedestrians from street volume-capacity ratio before stop-line for intersections types (t_{rest} – duration of the restrictive signal of a traffic light for pedestrians)

change depending from the lane width as it lays within 3.0–4.0 m. Lane width has no impact on pedestrian behavior but it depends from the roadway width (pedestrian crosswalk length). Average values of the number of violations the traffic rules by pedestrians for different day periods (with the aim to investigate the change of violations at the intersection with different volume-capacity ratio) is given on Figure 1.

Based on the obtained results, the tendency of decrease of the number of violations by pedestrians while crossing the roadway by street volume-capacity ratios is established: 0.50–0.65 for intersections of type I (duration of restrictive signal for pedestrians is 20–40 s); 0.40–0.65 for type II (duration of restrictive signal for pedestrians is 40–100 s); 0.45–0.55 for type III (duration of restrictive signal for pedestrians is 40–100 s). For the intersection of type III, with the duration of the restrictive signal of a traffic light for pedestrians is 100–120 s, an increase of the number of violations of the traffic rules by pedestrians regardless of roadway volume-capacity ratio is observed.

Research showed that street volume-capacity ratio and control regime are determinant factors in making a decision by pedestrians about crossing the roadway in risk conditions. With roadway volume-capacity ratios from 0.20 to 0.40, large intervals between vehicles are observed, pedestrians, feeling their relative safety, cross the roadway in risk conditions (especially such thing is observed during long restrictive signal). With the increase of roadway volume-capacity ratios (0.40–0.60), intervals between vehicles density, vehicles structure by composition on the lanes. This leads

to that pedestrians do not risk violating the traffic rules (cross the roadway on the restrictive traffic light signal). With volume-capacity ratios 0.80–0.95 (vehicle movement due to traffic jams is almost absent), the prevailing majority of persons decide to cross the roadway on the restrictive signal. In these conditions, the number of persons who wait for safe roadway crossing, i.e. with abidance of traffic rules, decreases.

Dependence of the number of violations of the traffic rules by pedestrians ($N_{\text{violations}}$), i.e. crossing the roadway during restrictive signal, from roadway volume-capacity ratio (z) is non-linear and can be described by the quadratic equation:

$$N_{\text{violations}} = a \cdot z^2 + b \cdot z + c \text{ [person}\cdot\text{h}^{-1}]$$

where:

a , b , c – coefficients of the power function.

Numerical values of coefficients are determined in the MATLAB software. Obtained results of the dependence of the number of violations the traffic rules by pedestrians from streets volume-capacity ratio for three types of intersections are given in Table 2.

Based on obtained dependencies for the second and third intersection types, we can confirm that the largest number of violators is observed with the duration of restrictive signal for pedestrians above 80 s – respectively about $N_{\text{violations}}$ is 90 and 50 $\text{person}\cdot\text{h}^{-1}$. This phenomenon appears for several reasons. The first is that due to the long waiting time for permissive signal, pedestrians decide crossing the roadway in risk conditions because at the intersection three or four-phase traffic light cycle operates. The second

TABLE 2. Dependence of the number of violations of the traffic rules by pedestrians in the zone of signalized intersections operation

Duration of the restrictive signal of the pedestrian traffic light [s]	Formulas	R^2	Number of formula
Intersection type I			
20–40	$N_{\text{violations}} = 1\,341.3 \cdot z^2 - 1\,562.6 \cdot z + 527.55$	0.89	2
Intersection type II			
40–60	$N_{\text{violations}} = 135.64 \cdot z^2 - 160.43 \cdot z + 83.757$	0.78	3
60–80	$N_{\text{violations}} = 156.23 \cdot z^2 - 184.17 \cdot z + 95.505$	0.74	4
80–100	$N_{\text{violations}} = 257.28 \cdot z^2 - 290.76 \cdot z + 126.83$	0.71	5
100–120	$N_{\text{violations}} = 318.14 \cdot z^2 - 360.83 \cdot z + 154.7$	0.70	6
Intersection type III			
40–60	$N_{\text{violations}} = 175.21 \cdot z^2 - 183.32 \cdot z + 60.92$	0.79	7
60–80	$N_{\text{violations}} = 162.68 \cdot z^2 - 171.22 \cdot z + 62.09$	0.77	8
80–100	$N_{\text{violations}} = 148.25 \cdot z^2 - 146.81 \cdot z + 59.96$	0.74	9
100–120	$N_{\text{violations}} = 75.63 \cdot z^2 - 67.45 \cdot z + 49.01$	0.73	10

is that with the increase of the number of persons which crowded near traffic light object waiting for the permissive signal most frequently a situation appears when one of the pedestrians decide crossing the roadway on the restrictive signal and a group of other pedestrians follows after him.

Determination of rational control parameters

Based on the results of field research indicators of traffic and pedestrian flows, and road network parameters, the choice of rational control regimes is justified. The rational regime of traffic light control was determined by such indicators as a share of the restrictive signal on the lane in traffic light cycle for traffic flow (respectively, permissive for pedestrians), street volume-capacity ratio, and maximal queue length on the approach

to the stop-line. Maximal queue length was determined to determine the potential impact of traffic flow delay on the adjacent intersections. We carried out the verification of correctness of listed indicators using the PTV Vissim software. Besides, we considered pedestrian behavior (number of violations the traffic rules by them) for three intersection types. With this aim, the model of a one-lane segment on the approach to the intersection (crosswalk) was created.

The research was carried out in the PTV Vissim software, where a one-lane roadway (3.75 m) was built with the length of 1,000 m, mixed traffic flow with the share of cars (for intersection type I – 70%; for II – 95%; for III – 80–85%) was created.

Primary data for traffic simulation were set, the intensity of vehicles in passenger car units changed from 50 to

700 pcu·h⁻¹. Lane capacity on the approach to the intersection was accepted 800 pcu·h⁻¹.

Traffic light object was created with one group of signals and the duration of the cycle was set 120 s with the structure red-green. The share of restrictive signal for traffic flow on the lane in the control cycle was determined by the equation $\beta = t_g / T_c$ (the duration of restrictive signal changed from 10 to 105 s). Besides, normative restriction $25 \leq T_c \leq 120$ s was taken into account, and the value of the main time duration for transport was no less than $t_g \geq 7$ s. The transitional interval of the pedestrian phase did not change, as the geometric parameters of the roadway are constant.

To determine the maximal queue length of vehicles before stop-line in different traffic light control regimes, we simulated traffic and pedestrian flows at intersections of three types (types I, II, and III).

Changes of the maximal queue length of vehicles depending on street volume-capacity ratio before stop-line and the share of restrictive signal duration on the lane in the control cycle are given in Figure 2.

Interrelation between satisfactions of pedestrian needs, based on the criterion of minimal number of violations, and traffic flow condition (by the criterion of vehicle queue length), based on planning features of roadway and traffic light control indicators for each type of signalized intersections and crosswalks is given in Figure 2.

Share of pedestrians that cross the roadway on the restrictive signal of a traffic light for intersections type I increases with the increase of restrictive signal duration. It indicates the need for

adjustment of traffic light cycle duration near the places of a large generation of pedestrian flow. Besides, reduction of permissive signal duration for pedestrians reduces waiting time for traffic flow what, within the intensity above 500 pcu·h⁻¹ by one lane, causes the formation of the vehicular queue by the length of more than 100 m with the restrictive signal 40 s (point A, Fig. 2).

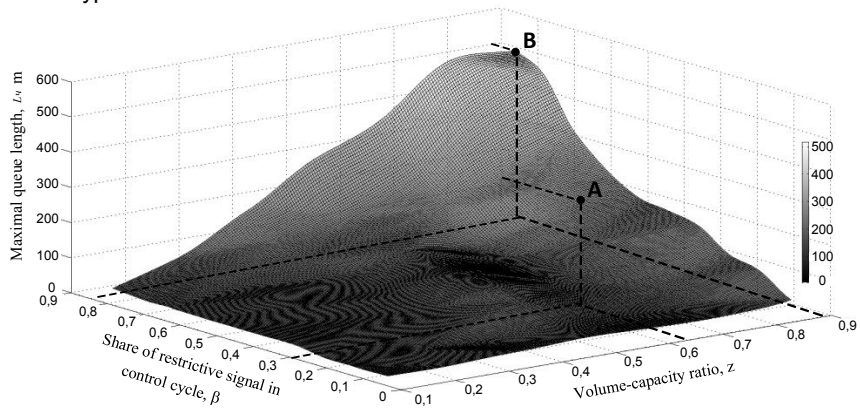
As simulation results show of the change of maximal queue length of vehicles before stop-line for different intersection types (Fig. 2), its maximal value is observed for intersection type I (near transport junctions) – 504.56 m with roadway volume-capacity ratio – 0.88 and the share of the restrictive signal on the lane in control cycle – 0.83 (point B in Fig. 2). If in analogical traffic light control regimes to compare the values of maximal queue length for intersection type II (central zone) and type III (residential zone), then we can confirm that vehicular queue length reduces and is respectively 353.65 m (point C in Fig. 2) and 257.88 m (point D in Fig. 2).

Discussion

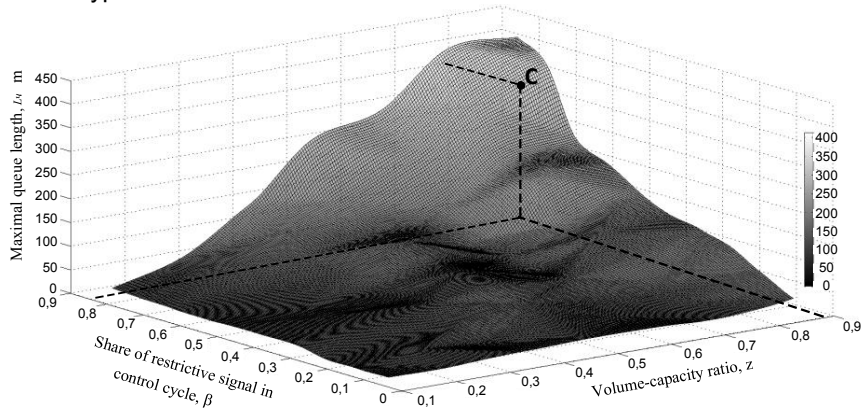
While choosing the rational regime of traffic light control, the necessary condition is considering psychophysiological and physical properties of people and forecasting their behavior.

Based on the results of experimental research (Fig. 1), simulation modeling (Fig. 2), and on the criterion of optimization of traffic flow delays, we developed recommendations about the choice of rational regimes of traffic light control

Intersection type I



Intersection type II



Intersection type III

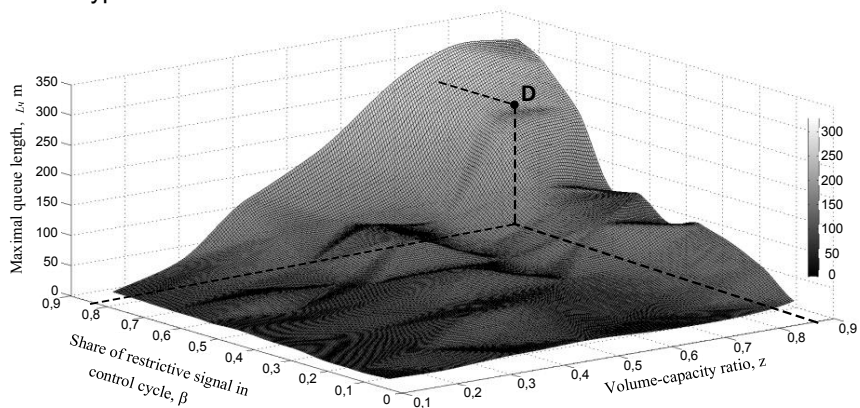


FIGURE 2. Changes of maximal queue length of vehicles depending on roadway volume-capacity ratio before stop-line and the share of restrictive signal duration on the lane in the control cycle

TABLE 3. Recommendations about the choice of rational regimes of traffic light control depending on traffic delay and pedestrian behavior

Street volume-capacity ratio (z)	Recommended duration of the restrictive signal of a traffic light for pedestrians [s]		
	intersection type I	intersection type II	intersection type III
Two phases			
$z < 0.2$	10–15	10–20	10–25
$0.2 \leq z < 0.45$	10–20	10–30	10–30
$0.45 \leq z < 0.7$	15–30	30–50	30–50
$0.7 \leq z < 1.0$	25–30	45–55	50–65
Three phases			
$z < 0.2$	10–20	10–30	10–30
$0.2 \leq z < 0.45$	15–25	20–45	25–50
$0.45 \leq z < 0.7$	20–35	35–50	40–60
$0.7 \leq z < 1.0$	35–40	40–65	60–90
Four phases			
$z < 0.2$	10–20	10–35	10–40
$0.2 \leq z < 0.45$	20–30	25–50	40–75
$0.45 \leq z < 0.7$	30–40	40–60	60–95
$0.7 \leq z < 1.0$	40–50	60–90	75–110

(duration of restrictive signal for pedestrians) taking into account pedestrian behavior (Table 3).

Based on the data, given in Table 3, the least amount of violations of the traffic rules by pedestrians while crossing the roadway and the average vehicular queue length on one approach to the signalized intersection will be observed under the condition of limitation of the duration of restrictive signal for pedestrians:

- for two-phase control: intersection type I – to 30 s, type II – to 55 s, type III – to 65 s;
- for three-phase control: intersection type I – to 40 s, type II – to 65 s, type III – to 90 s;

- for four-phase control: intersection type I – to 50 s, type II – to 90 s, type III – to 110 s.

Such recommendations are advised to provide in current regulatory documents about the regulation of traffic light control implementation at the intersections of city streets and roads, as for today only minimal and maximal limitations of traffic light cycle duration operate, which are 25 s and 120 s respectively. It should be noted that principles of design of traffic and pedestrian phases are justified only by criteria of absence of conflict and limitations of minimal traffic intensity (to $120 \text{ pcu}\cdot\text{h}^{-1}$) and pedestrian intensity (to $900 \text{ person}\cdot\text{h}^{-1}$).

Conclusions

1. For signalized intersections with different conditions of traffic and pedestrian flows, it is established that these conditions depend on the location relative to the territory of the city. Considering this, intersections are grouped by movement peculiarities (traffic flow intensity and composition, the existence of centers of pedestrian flow generation) on three types: type I – near transport junctions; type II – central zone; type III – residential zone.
2. It is determined by results of experimental measurements that for different intersection types in existing movement conditions, the smallest number of violators among pedestrians with the duration of restrictive traffic light signal for pedestrians 40–60 s is by roadway volume-capacity ratio 0.50–0.65 for intersection type I; 0.40–0.65 for type II; 0.45–0.55 for type III.
3. By results of simulation results, it is determined for intersection type I that the largest vehicular queue is 504.56 m by roadway volume-capacity ratio 0.88 and the share of restrictive signal for traffic on the lane – 0.83. If at these traffic light control regimes, to compare the values of maximal queue length for intersection type II (central zone) and type III (residential zone), then queue length reduces and is about 353.65 m and 257.78 m respectively.
4. By results of experimental research and simulation of the passage signalized sections of city streets by traffic flow (using the PTV Vissim and the

MATLAB software) considering the needs for pedestrian movement, and, taking into account the regularities of vehicular queue formation, it is established that limitation of restrictive signal for pedestrians, regardless of the number of control phases, should not be more than: on the sections of type I – 50 s; type II – 90 s; type III – 110 s. Such time limitations of traffic light control parameters meet the criteria of delay minimization for traffic flows and the least amount of violations the traffic rules by pedestrians.

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Summary

Choice of the rational regimes of traffic light control for traffic and pedestrian flows. The method for the choice of rational regimes of traffic light control is developed based on the minimization of the number of violations the requirements of traffic light

signals by pedestrians depending on the volume-capacity ratio of traffic lanes and control of vehicular queue on the approach to the stop-line. Assessment of rationality is carried out considering the simultaneous impact of such factors as roadway volume-capacity ratio, traffic light restrictive signal duration, the number of violations of the traffic rules by pedestrians, and maximal queue length of vehicles. The model of the change of the number of violations of the rules of crossing the roadway by pedestrians depending on the volume-capacity ratio of different intersection types is developed in this paper. The model of determining the maximal vehicular queue length before intersections depending on the volume-capacity ratio and the share of the restrictive signal on the lane in the control cycle is developed. Recommendations about the choice of rational regimes of traffic light control depending on traffic delay, planning parameters of the road network, and pedestrian behavior are proposed.

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