Technical science and innovation

Volume 2022 | Issue 1 Article 7

4-15-2022

EFFICIENCY OF FUNCTIONING OF INTERSECTIONS WITH HIGH-INTENSITY TRAFFIC AND PEDESTRIAN FLOWS

Aziz Ernazarov
Andijan machine- building Institute, aziz-ernazarov@mail.ru

UDC 656.054

EFFICIENCY OF FUNCTIONING OF INTERSECTIONS WITH HIGH-INTENSITY TRAFFIC AND PEDESTRIAN FLOWS

A.A. Ernazarov
Andijan Machine Building Institute,
Bobur shokh St,56 170100, Andijan city, Republic of Uzbekistan

Abstract: *The article studies the interaction of traffic and pedestrian flows with high intensity at regulated intersections to improve the capacity of such intersections. To study the parameters of traffic flows, in particular, the length of traffic jams, a traffic flow model was used. To study the parameters of traffic flows, in particular, the length of traffic jams, a traffic flow model was used, which includes a psychophysiological model of following a vehicle that moves in front, for the longitudinal movement of vehicles and a model that is based on the rules of the road, for turning traffic. The research methodology presented in this paper can be used for intersections with another traffic management scheme in order to justify the feasibility of introducing three-phase traffic light regulation when one of the phases allows only pedestrians to move.*

Keywords: *transport technologies, traffic organization, traffic delays, congestion length, pedestrian intensity, traffic flow intensity.*

INTRODUCTION. Transport delays negatively affect the transport process, leading not only to a decrease in speed and an increase in the duration of transportation, but, as a result, to economic losses. The longest delays in the city are observed in its central part, where a large number of places of generation and attraction of pedestrian and traffic flows are concentrated, such as institutions of higher education, shopping malls, entertainment venues, theaters, cinemas, museums, etc. Problems may arise if the intensity of pedestrian traffic through regulated intersections increases, since in this case it becomes difficult for cars moving in turning directions to pass the intersection.

In this case, vehicles making a left or right turn at an intersection, when passing an intersection at a traffic light signal that permits movement, must give way to pedestrians crossing the carriageway at a pedestrian crossing. In case of high intensity of pedestrian traffic, it is impossible to complete a turn for these vehicles, therefore, significant traffic delays occur behind these vehicles [1].

The study of traffic flows at regulated intersections in order to optimize traffic light regulation is investigated, in particular in [2]. The authors consider the influence of the presence of trucks as part of traffic flows on the duration of the resolving signal of the traffic light for this direction. The authors of the article [3] orient the work of traffic lights to reduce the travel time of a regulated intersection by trams by giving them transit priority, taking into account the traffic schedule. Despite the effectiveness of using methods that allow to increase the capacity of the intersection for individual directions, these works do not take into account the needs of all road users. Therefore, the authors of the work [4] propose to predict traffic parameters at an intersection based on statistical data about it for the introduction of multi-program traffic light regulation at an isolated intersection.

However, greater efficiency can be achieved by using adaptive traffic light regulation. So, in the work [5], a technique based on the determination of traffic parameters in all directions of traffic is proposed, which allows you to effectively control traffic conditions at the intersection, and then dynamically adjust the maximum green

time of the traffic light. In addition, optimization of the intersection capacity is also considered by other authors, in particular, in [6] - using a multi-agent approach, in [7] - hierarchical fuzzy systems, in [8] - the method of detecting route vehicles with coordinated traffic light regulation. However, these works do not take into account the interaction of traffic and pedestrian flows. This phenomenon has been investigated in a number of other works, in particular [10], but they do not consider the influence of pedestrian flows on transport delays.

MATERIAL AND METHODS. To study the parameters of traffic flows, in particular, the length of traffic jams, a traffic flow model was used, which includes a psychophysiological model of following a vehicle that moves ahead for the longitudinal movement of vehicles and a model that is based on the rules of the road for lateral movement. These models were developed based on the results of Weidman's research [13, 14]. To model pedestrian flows, the Weidman model is also used, which provides for non-free movement of pedestrians, but purposeful, by analogy with traffic flows. To obtain empirical nonlinear dependences of the length of congestion on the intensity of conflicting pedestrian and traffic flows, the least squares method was used.

RESULTS AND DISCUSSION. To improve the capacity of regulated intersections with a high intensity of conflicting pedestrian and traffic flows, it is necessary to conduct a study of the length of traffic delays and identify factors affecting the formation of traffic jams. To do this, consider a four-sided adjustable crosshair (Fig. 1). The diagram of the phase-by-phase connector is shown in Fig. 2. There are three lanes in the direction I-II. In the direction of III-IV and IV-III, one lane is provided for traffic in each direction.

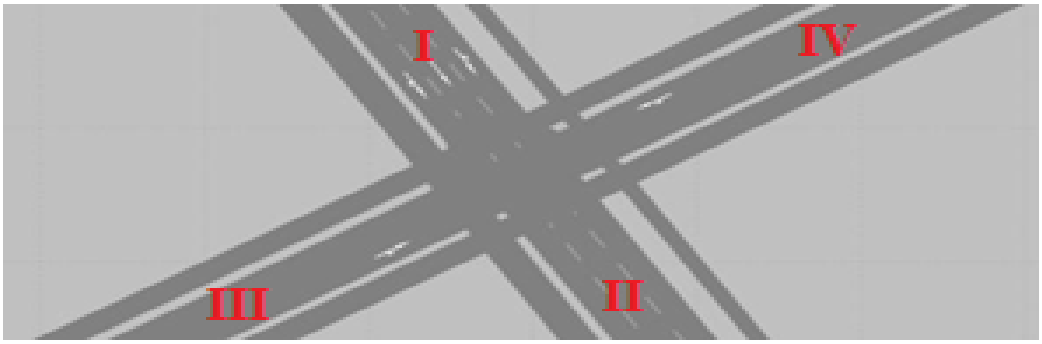

Fig. 1 Traffic diagram at the intersection

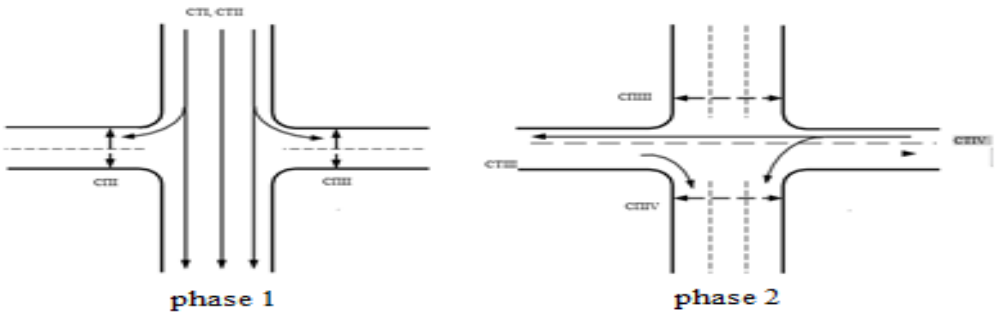

Fig. 2 Diagram of the phase-by-phase junction at the intersection

Two-phase traffic light regulation is installed at the intersection under study. The first phase permits the movement of vehicles in the direction I- II, I-III and I-IV, as well as pedestrians in the direction I-II and II-I. The second phase permits traffic in directions III - IV, IV-III, III-II and IV-II, as well as pedestrians in directions III-IV and IV-III. When making a right turn when driving in the direction I-III and left in the direction I-IV, traffic delays occur due to the inability to pass through the pedestrian crossing due to the high intensity of pedestrian traffic.

The first phase permits the movement of vehicles in the direction I-II I-III and I-IV, as well as pedestrians in the direction I-II and II-I. The second phase permits traffic in directions III-IV, IV-III, III-II and IV-II, as well as pedestrians in the direction III-IV and IV-III. When making a right turn when driving in the direction I-III and left in the direction I-IV, traffic delays occur, this traffic management scheme corresponds to the intersection on Sh Avenue. Rashidova and Baynalminal Street in Jizzakh. There is a high intensity of pedestrian and transport traffic on this section of the road network of the city of Jizzakh. The cyclorama for such an intersection has the form shown in Fig.3

To study the dependence of the length of traffic jams on the intensity of traffic and pedestrian flows, the conflicting traffic flows I-III and pedestrian – I-II, II-I. are considered. In the PTV Vissim environment, this intersection is modeled with the following parameters: the width of the lane for traffic is 3.5 m; the width of pedestrian crossings is 4 m; the traffic light control cycle is 50 s; the traffic light signal for direction I-II is 20 s; the total intensity of traffic flow in the direction I-II, I-III and I-IV is 1500 auth./h; total intensity of traffic flow in the direction III-IV, III-II – 30 auth./h; the total intensity of traffic flow in the direction of IV-III and IV-II is 600 vehicles/hour. The intensity of the right-turning traffic flow I-III during the simulation varied in the range from 100 to 700 autos/hour in increments of 100 autos/hour.

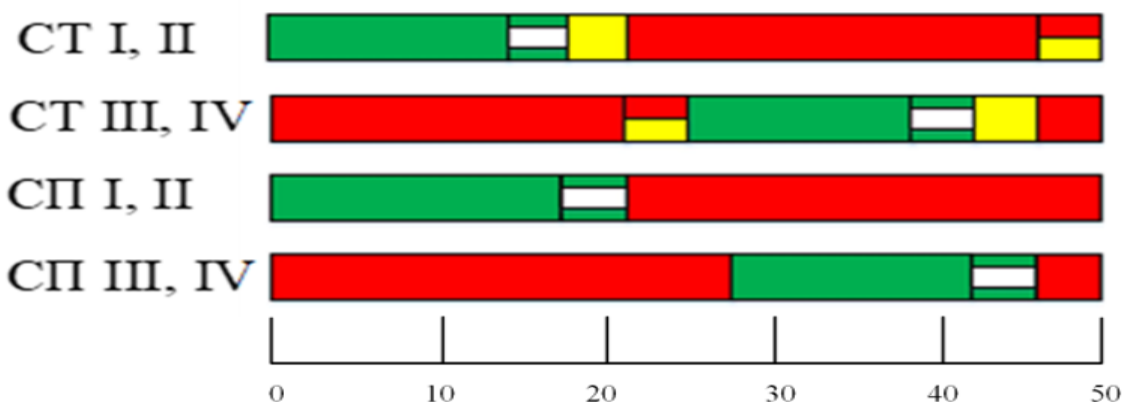

Fig. 3. Traffic light regulation cyclogram at the intersection

The intensity of pedestrian traffic I-II, II-I during the simulation varied in the range from 500 to 2000 people/h in increments of 500 people/hour. The initial data was information about the length of the jam in the direction I-II. The simulation results are presented in Table 1.

Table 1

Length of congestion, m, depending on the intensity of conflicting traffic and pedestrian flows

Pedestrian flow intensity I-II, II - I, People / time	Transport intensity stream I-III, auth. / time				
	100	250	400	550	700
500	78	161	182	288	362
1000	95	163	255	318	406
1500	98	172	262	320	410
2000	98	172	262	333	410

As we can see from Table 1, the length of congestion significantly depends on the intensity of traffic flow. There is also a dependence of the change in this parameter on

the intensity of pedestrian traffic. However, with an increase in the intensity of pedestrian traffic of more than 1000 people / hour, the length of congestion changes insignificantly after processing the simulation results using the least squares method, such an empirical dependence was obtained for determining the length of congestion, m, depending on the intensity of conflicting traffic and pedestrian flows, taking into account the presence of non-rail vehicles:

$$L = 1.1N_n^{0.137}(0.01 * \alpha * N_{\text{тр}})^{0.743} \quad (1)$$

where N_n is the intensity of the pedestrian flow, person/h; Nтр is the intensity of the traffic flow on the approach to the intersection, the return fraction of which conflicts with the pedestrian flow, auth./ h; α is the proportion of the return flow that conflicts with the pedestrian flow, %. Figure 4 shows the graphical dependence of the length of congestion on the intensity of conflicting traffic and pedestrian flows in order to reduce congestion on conflicting directions of traffic flows at high traffic and pedestrian traffic intensities, it is proposed to change the traffic light regulation program with the introduction of an additional phase that would allow pedestrians to move in all directions, while traffic is prohibited for vehicles in all directions. At the same time, during the next two phases, only vehicles are allowed to move, pedestrians are prohibited.

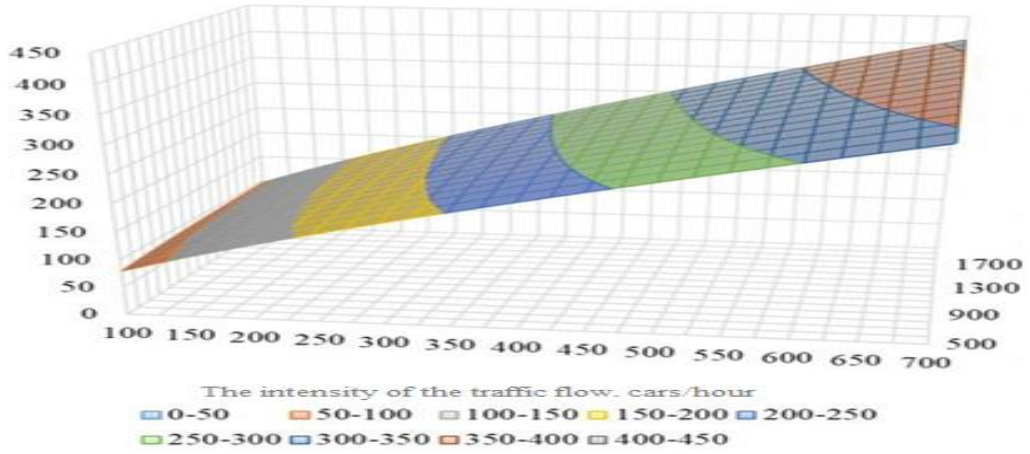

Fig. 4-Graphical dependence of the length of congestion on the intensity of conflicting traffic and pedestrian flows

It is known that it is recommended to combine the return flow and the pedestrian flow in one phase, provided that the intensity of such a flow does not exceed 120 auth./ hour, and the intensity of pedestrian traffic does not exceed 900 people / hour. Therefore, to ensure a "conflict-free" pedestrian pass, it is proposed to introduce an additional 3rd phase. The cyclogram for such an intersection, taking into account the presence of the third phase for pedestrians, will have the form shown in Fig. 5. When modeling in the PTV Vissim 2021 environment, the traffic light control cycle was increased by 13 seconds, 10 of which for pedestrians to pass in all directions, 3 for an additional clock cycle.

The simulation results, taking into account the introduction of three-phase traffic light regulation, when one of the phases allows only pedestrians to move, are shown in Table 3. As you can see, with the introduction of three-phase traffic light regulation, when one of the phases allows only pedestrians to move, the length of congestion at the intersection decreases by an average of 45.3% and does not depend much on the intensity of pedestrian flows. So, for example, for the intensity of traffic flow of 400 cars / hour and pedestrian - 500 people / hour, such a measure will entail an increase in the

length of congestion by 7.5%.

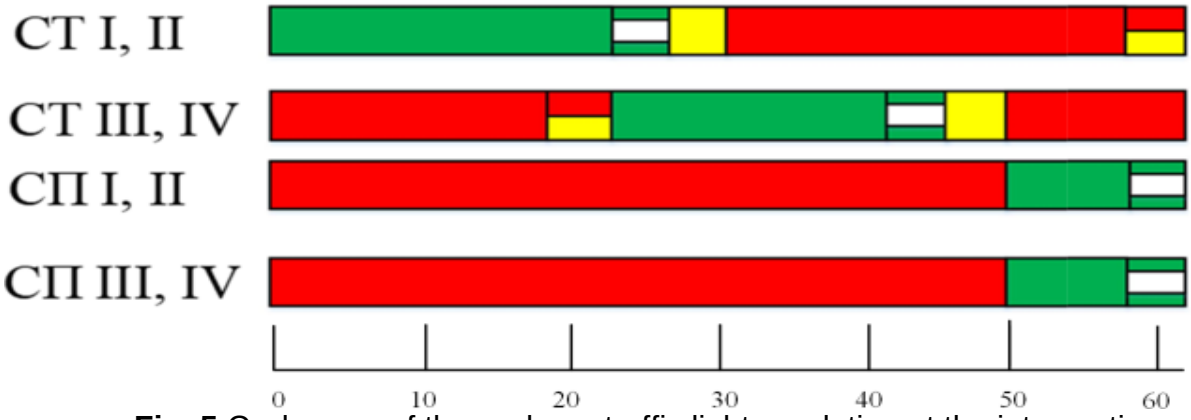

Fig. 5 Cyclogram of three-phase traffic light regulation at the intersection

Therefore, at the intersection, it is necessary to justify the application of such a measure on the basis of modeling the traffic management scheme at the intersection with the introduction of traffic parameters obtained on the basis of field studies.

Table 3

The length of congestion, m, depending on the intensity of conflicting traffic and pedestrian flows after the introduction of three-phase traffic light regulation, when one of the phases allows only pedestrians to move

Pedestrian flow intensity I-II, III, person / time	Traffic flow intensity I-III, auth. / hour				
	100	250	400	550	700
500	29	44	147	232	322
1000	29	46	155	213	305
1500	29	48	131	253	294
2000	29	47	155	235	294

CONCLUSION. The study of the parameters of road and pedestrian traffic at the intersection showed that the length of traffic jams significantly depends on the intensity of traffic flow, however, with an increase in the intensity of pedestrian traffic of more than 1000 people / h, the length of congestion changes slightly. With the introduction of three-phase traffic light regulation, when one of the phases allows only pedestrians to move, the length of congestion in the case decreases by an average of 45.3% and does not depend much on the intensity of pedestrian flows. The research methodology presented in this paper can be used for intersections with another traffic management scheme in order to justify the feasibility of introducing three-phase traffic light regulation, when one of the phases allows only pedestrians to move.

The initial data for determining the feasibility of introducing three-phase traffic light regulation, the intensity of traffic and pedestrian flows on the approach to the intersection, as well as the proportion of turning traffic flow that conflicts with pedestrian traffic. The obtained value of the length of the congestion, calculated according to the formulas (1). In the case of obtaining intermediate values of the intensity of traffic and pedestrian flows, the linear interpolation method should be applied. If the tabular value of the congestion length is less than the value calculated according to dependence (1), it is advisable to introduce a third phase of traffic light regulation at the intersection to allow pedestrians to pass.

References:

1. A. Renkas, V. Tovaryansky. Research of traffic organization at regulated intersections with heavy pedestrian traffic. All-Ukrainian scientific and technical conference. "*Modern trends in the development of mechanical engineering and transport"*. **2020**. 170.
2. A. Novikov, A. Katunin, I. Novikov, A. Shevtsova. Research of influence of dynamic characteristics for options controlled intersection. "*Procedia Engineering".* **2017**. 664.
3. Sh.J. Sun, Y.P. Schonfeld, J.Qi. Joint optimization of tram timetables and signal timing adjustments at intersections. "*Transportation Research Part C: Emerging Technologies"*. **2017**. 104.
4. S. Coogan, C. Flores, P. Varaiya. "*Traffic predictive control from low-rank structure. Transportation Research Part B: Methodological*". **2017**. 22.
5. M.S. Shiri, H.R. Maleki. Maximum green time settings for traffic-actuated signal control at isolated intersections using fuzzy logic. "*International journal of fuzzy systems".* **2017**. 247.
6. X.M. An, K.L. Vu, Y.Z. Feng, J.E. Chen. Optimizing multi-agent based urban traffic signal control system. *"Journal of Intelligent Transportation Systems*". **2018**. 357.
7. V.N. Afanasiev. "*Management of uncertain systems*". **2008**. 325.
8. R. Dorf, R. Bishop. "*Modern control systems*". **2002**. 822.
9. N.D. Egupov, K.A. Pupkov. Methods of classical and modern theory of automatic control. "*Publishing house*". **2004**.
10. V.A. Kostin. "*Control theory*". **2004**. 224.
11. A.N. Tikhonov, A.S. Leonov, A.G. Yagola. "*Nonlinear ill-posed problems*". **1995.** 308.
12. A.A. Fonarev. "*Projection iterative methods for solving equations and variation inequalities with nonlinear operators in the theory of monotone operators Publisher"*. **2017**. 201.
13. A.B. Bakushinsky, M.Y. Kokurin. *"Iterative methods for solving irregular equations".* **2006**. 214.
14. A.A. Fonarev. "*Projection iterative methods for solving equations and variation inequalities with nonlinear operators in the theory of monotone operators Publisher"*. **2017**. 201.
15. N.V. Le, J.P. Panchenko. Pre-processing of speech signals for speech recognition system. "*Young Scientist*". **2011**. 74.
16. R. Li, X. Shujing. "*Traffic signal control using genetic decomposed fuzzy systems. international journal of fuzzy systems*". **2018**. 1939.
17. M. Yang, G. Sun, W. Wang, X. Sun, J. Ding, J. Han. "*Evaluation of the pre-detective signal priority for bus rapid transit: coordinating the primary and secondary intersections".* **2018**. 41.
18. Y. Zheng, L. Elefteriadou, T. Chase, B. Schroeder, V. Sisiopiku. "*Pedestrian traffic operations in urban networks. transportation research procardia"*. **2016**. 137.
19. Y. Zhang, K. Gao, R. Su. (2018). Traffic light scheduling for pedestrian-vehicle mixed-flow networks. "*IEEE Transactions on intelligent transportation systems".* **2018**. 1468.
20. R. Wiedemann. "*Simulation of road traffic flow. Series of publications by the Institute for Transport at the University*". **1974**.
21. R. Wiedemann. "*Modelling of RTI-Elements on multi-lane roads. In: Advanced Telematics in Road Transport edited by the Commission of the European Community".* **1974**.