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Procedure for Calculating On-Time Duration of the Main Cycle of a Set of Coordinated Traffic Lights

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Abstract

The task of enhancing efficiency of traffic lights operation demands optimization of the throughput capacity of a regulated street and road network junction including rational and full use of an operation cycle of traffic lights. Oftentimes, the existing calculation system for an operation cycle of traffic lights at intersections does not provide a jam-free and safe route for transport in rush hours. In this article the authors suggest a new calculation methodology for an operation cycle of traffic lights based on the expert calculation which considers the necessity for keeping the possibility of entering a crossing by all vehicles that have arrived to a crossing from each of conflicting directions (including the most loaded one) during one cycle; the use of vehicles slow-down rate called in the traffic rules as “without emergency braking”; the use of phase coefficients at the calculation of the main cycles of the less loaded directions.

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Keywords: traffic safety; main cycle of traffic lights; “without emergency braking”; phase coefficients; street and road network; throughput capacity

1. Introduction

A crossing is one of the most difficult and dangerous junctions of a street and road network with the highest concentration of conflict points [Almetova (2003)]. The current calculation system for the traffic lights operation cycle at crossings in the majority of cases does not provide a jam-free and safe route for transport in rush hours

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[Gorodokin and Almetova (2015)[3]]. Alongside with that, crossings are the place of concentration of accident-prone areas and road traffic incidents [Pogotovkina et al. (2015)]. This article is devoted to solving this problem. In order to increase the throughput capacity and decrease of road traffic incidents probability the authors suggest a new calculation methodology for one of the elements of traffic lights operation — the main cycle. The suggested methodology is based on the current approach used by motor vehicles experts in calculations of technical feasibility as to performance of certain actions by drivers: technical operations while driving vehicles [Puchkin (2010)]. The methodology principally differs from the F. Webster's methodology, its main drawback being impossibility of calculating the main cycle at crossings of multilane roads with high flow value [Webster and Cobbe (1966)]. In the course of performance of the specified calculations the main focus is put firstly on the necessity for keeping the possibility during one cycle of entering a crossing by all vehicles arrived to from each of conflicting directions including the most loaded one and secondly on the use of vehicles slow-down rate called in the traffic rules as "without emergency braking", and thirdly the use of phase coefficients at calculation of the main cycles of the less loaded directions [Evtiukov and Vasiliev (2006)]. As the concluding stage of calculation of the main cycle, the authors suggest the checking calculation correcting the obtained result proceeding from the possibilities of crossing a carriage by pedestrians and by tramcars for which the time required for crossing and defined by the calculation may be insufficient for the safety of traffic.

2. Main text

One of the most important problems connected with operational losses in the automobile industry is the provision of a jam-free passing through street and road network junctions [Klinkovshtein (1981)]. The traffic lights may be considered as the traffic regulation element allowing for the optimization of crossing throughput capacity [Kremenets and Pecherskiy (1981)]. In its turn, the efficiency of the work of the traffic lights is to be assessed on the basis of the possibility of passing through a crossing during one full operation cycle by vehicles that have arrived [Gorodokin and Almetova (2015)[2]]. Thereby calculation of the traffic lights operation cycle is one of few possible elements allowing enhancing the automobile transportation efficiency and decreasing the probability of road traffic incidents at minimum financial costs [Gorodokin and Almetova (2015)[1]]. It may be achieved by means of more correct and scientifically grounded calculation for the main and interim cycles of the traffic lights operation. This article suggests the new approach to the calculation of the optimal duration for the main cycle.

Therefore, according to the applicable methodological recommendations one full cycle duration of traffic lights is not to exceed 120 seconds [Gorodokin and Kudryavtseva (2015)]. Upon known hourly activity of vehicles on the most loaded direction at a crossing (N_a) first the number of vehicles arriving to a crossing during the specified time interval (N_a^i) is defined.

$$N_a^i = \frac{N_a \cdot 120}{3600} \tag{1}$$

where N_a^i — the traffic flow value on the considered direction during the cycle, un / 120 sec; N_a — the traffic flow hourly value on the considered direction.

Note. In the course of performing of the above-mentioned calculation one is to understand that the highest value of the traffic vehicle is to be defined not on the entire direction, but along the direction having the maximum flow value on one lane.

The main condition determining the single main cycle of the traffic lights is providing for this direction the required time interval sufficient for the turn-based entrance of the crossing by the carriages by all the vehicles that have arrived to a crossing during the cycle. Proceeding from this condition, the longest duration is required for a certain vehicle which has arrived to a crossing last. The right of a driver of such vehicle to enter a crossing directly depends on the distance of its staying from the place established by the traffic rules for the successive stop in the moment the restrictive yellow signal is on. According to cl. 6.13 of the traffic rules "the moment the restrictive signal is on (except for the reverse one) or made by the regulator drivers shall stop in front of the stop-line (6.16), if the latter is non-available:

- At a crossing — in front of the crossed carriage (as per 13.7 of the Traffic Rules) without interference with pedestrians;