INCREASED SAFETY ROAD TRANSPORTER

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ABSTRACT
The article is focused on road transport. The most wide spread element in ensuring the continuity and safety of traffic is light-signaling device. The mentioned safety element controls via light signals and that is why we classify it among control systems. It controls the road users by using the states of the light signaling device. It is possible to find some deficiencies between the states that increase the risk of extraordinary incident. After an extraordinary incident, the flow of traffic is disrupted. After analyzing and simulation of corrective measures for specific traffic light systems, it is possible to reduce the risk to an acceptable level. By comparing each state at traffic lights, it is possible to avoid risky situations and minimize the risk of accidents this way.

Keywords: traffic light, road transporter, critical infrastructure.

1. INTRODUCTION

One of the important elements in ensuring of the road traffic safety and fluency is the light signaling device. A widespread alternative of the traffic management is using lights signaling devices. Crossroads controlled by light signaling devices are strongly influenced by the quality of the proposed signal plan. Every crossroad controlled by a light signaling device has to have a fixed signal plan. In the Czech Republic the fixed signals are based on the technical conditions of the Ministry of Transport no. 81 TP "Designing light signaling devices for road traffic. (Martolos J., 2015)
We can find crossroads that are controlled without any fixed signaling plan. These crossroads are equipped with different detectors that control this crossroads. When controlling via these technologies there are only set some priorities for the individual directions and some conditions for the proper operation of the crossroad. However, we can find crossroads with that procedure only in cases where the traffic density is low. Above mentioned roads are not so busy and the number of vehicles is only in hundreds per day.

2. LIGHT SIGNALLING DEVICE

Light signaling devices are mostly set up in order to improve safety on the roads. Just additional reason for their set up is to control the flow of traffic. Due to the conflicting interests of the various participants in traffic on the land roads, it is not possible to satisfy all. Only the legitimate demands of the participants can be satisfied. To be able to initiate a control of the crossroad by light signaling device at least one of the following criteria has to be fulfilled: (Martolos J., 2015)

- Criterion of traffic safety.
- Criterion of traffic intensity from the point of view of vehicles.
- Criterion of traffic intensity from the point of pedestrians.
- Criterion of fluency of traffic of public transport vehicles.

3. CRITERIA OF TRAFFIC SAFETY

In framework of the traffic safety, the light signaling devices are design only for crossroads with many accidents and high load. The above-mentioned crossroads must meet the following criteria: (Martolos J., 2015)

- In last three years there must be at least four traffic accidents per million vehicles entering the crossroad when the crossroad is not controlled via light signaling device
- Evidence of the accident rate based on an analysis where you cannot prevent the occurrence of extraordinary events another way.

From the point of view of safety, it is also necessary to consider the place calling for safety. Most of them are places where children crossing the road to school, etc. The above-mentioned localities need to be assessed individually in order to reflect all necessary conditions according to Czech standards CSN 73 6101 and CSN 73 6110. (CSN 73 6101, 2000)
From the point of view of pedestrians, it is necessary to establish light signaling devices where they pass through roads with more than just one lane in one direction. It should be noted that it is impossible to ignore pedestrian crossings which do not meet the conditions required by CSN 73 6110. (CSN 73 6101, 2000).

3.1. Criteria of traffic intensity from the point of view of vehicles

Light signaling device is effective on condition that the intensity of traffic exceeds the values than are the specified ones. These values are determined by allowed intensities of the uncontrolled crossroad according to CSN 73 6102. This is an average of eight hours with the most loaded traffic of the main and minor road. Roughly, we can assess the crossroad capacity using the chart illustrated on figure 1. Using the calculation, we can assess this fact more accurately. In cases where the access of vehicles on the main road is not, a random one we can take into our account also the possibility of influencing the surrounding crossroads. An individual approach is always necessary.

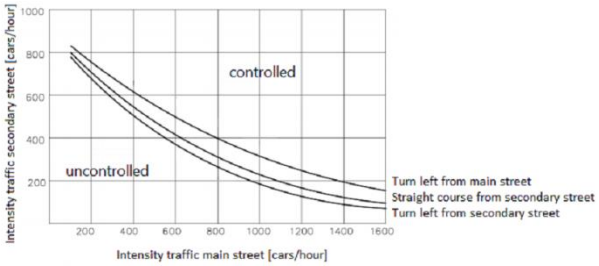

Figure 1 criterion of traffic intensity for the set up of a traffic light (Martolos J., 2015)

3.2. Criteria of traffic intensity from the point of view of pedestrians

Light signaling device is useful if the intensity of traffic on the relevant pedestrian crossing achieves values of an average of eight hours of the most loaded traffic higher than the limit value of the traffic intensity, which pedestrians can, under normal conditions, according to the rules of road traffic pass safely:

- 1100 vehicles per hour - crossing over one or two-lane.
- 1000 vehicles per hour - crossing over the three-lane.
- 900 vehicles per hour - crossing over four-lanes or undivided more directional lane.

Light signaling device fulfill the purpose when it reaches the appropriate intensity of traffic on the relevant pedestrian crossing.

On condition that the above-mentioned criteria are not met then we can assess the set-up of a pedestrian crossing from the following perspective. In the case where pedestrians disrupt the smooth flow of the traffic stream of the coordinated bundle of vehicles. These cases cause an increased risk of dangerous situations because of the unwillingness to allow pedestrians to cross the road.

3.3. Criterion of fluency of traffic of public transport vehicles.

Public transportation is important for each city. All cities prefer this way of transport to the individual car traffic. It is focused not only on improving passenger comfort but also for its attractiveness. Ensuring of the quality of the public transport operation can cause a reduction in traffic load from individual car transport.

For proper function of the public transport there must be taken into account not only the utilization of the public transport vehicles but also the long-term economic perspective. From that point of view, it is possible to arrange financial savings in the number of vehicles operating on the line but also the unnecessary energy consumption during starts.

In all these cases, it is necessary to assess the situations individually. Every crossroad is different. The environment that affects the set-up of a traffic light is different from case to case. Input parameters are indeed still the same, but the process cannot be evaluated the same way.

4. SYSTEM CONTROLLED BY LIGHT SIGNALING DEVICE

In everyday life, we encounter the light signaling device at almost every step. These devices have a variety of applications. We can find its use not only in the road transport but also in other parts of transport as in rail or water transport. In road transport, we often meet the concept of traffic lights, which displayed the particular instructions with color. These instructions are shown in. (Mrazek J., Duricova L. and Hromada M., 2016)

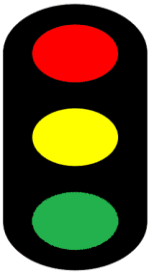

Figure 2 Semaphore [author]

Individual color displays directions that we learned from our parents. Red signal tells us instruction to stop or stand. In case that the red signal lights together with the yellow one, we can prepare for the close change of the signal to green. Green signal tells us that we can go. At the traffic light, we can see that sometimes the only visible signal is the yellow flashing light. It is a situation where it is necessary to act cautiously due to malfunctioning of traffic lights at the crossroad. (Mrazek J., Duricova L. and Hromada M., 2016). Such situations are often very dangerous because of the ignorance or disregarding of the traffic signs.

5. GENERAL CHARACTERIZATION OF THE METHODS

Individual methods can be divided into two categories. In the first category, we are talking about the decomposition approach, which has its own history. At times when this approach was applied, the computer equipment had a very low performance in comparison with the present time. The integration of the second

approach is much easier not only for the IT technologies but also "on sight". The reason why this is so is in the complexity. The exact approach is only one step in comparison with the three ones that use decomposition approach. No we learn more about the different steps of the mentioned methods.

5.1. Decomposition approach

In earlier times the computer technology was not so developed. That was why it was necessary to divide the decomposition approaches into three subtasks in order that even less powerful computer could them to handle.
In the first subtask, we must cover the set of flows occurring in solved crossroad by the minimum set of maximal subsets mutually non-collision flows.(Krejci, L., 2011)
This process can be described as the search phase, which runs in two steps. In the first steps, the system searches all subsets of maximum non-collision flows. For this purpose there is created a graph of the collision-free traffic where the flows are converted into a set of vertexes of graphs and collision-free. (Krejci, L., 2011)
Then we leave pairs of conflict flows without connecting edge. The task is to find the most complete subgraphs in this graph. It means to follow the graph vertices, which are joined by an edge with all the other vertices, and it is not possible to find any other peak that would satisfy this condition. (Krejci, L., 2011)
After locating all stages, the second step of the task is coming. The condition for the second step is that all traffic flows entering the crossroad are contained in at least one of the selected pairs. For this reason, it was built a simple linear programming model. (Krejci, L., 2011)
A second subtask is focused on the optimal alignment of the selected phase. In this step, we add a decisive split times between phases. This criterion is necessary in order that we can minimize non-productive times of the crossroad. To solve this criterion we can used Little algorithm. The outcome of this subtask is the fixation of the positions phases, including the greens, for various streams toward others. (Krejci, L., 2011)
The third subtask determines the optimal times of beginnings and ends of green in the cycle for all streams. Last subtask is solved using linear programming model with the selected optimization criterion. The model operates with two sets of variables, which can be integer or non-negative real values. Variables set start and end times for each of the green stream for the given streams. Another variable is selected according to the used criterion. It can be selected either the cycle length or a relative minimum reserve. If you choose the selected cycle lengths, you may choose the relative reserve that is maximalized by the model. Another possible criterion might be the sum of the length of waiting vehicles, which is minimized, and we can also select the length of the cycle. (Krejci, L., 2011)

5.2. Exact approach

The model contains two sets of variables for modeling the start and end times of greens for individual streams and variable depending on the selected optimization criteria. Mentioned step can be compared with the subtask three of the previous approach. The difference can be found in the fact that the model contains two more sets of bivalent variables. The first set is focused on the position of the beginnings and ends of green for individual streams. We evaluate whether the greens have a natural position. If the value of the beginning of the green is lower than the value of the green end, we mention that its position is one of the border of two cycles. A similar philosophy has set bivalent variables. The difference is in fact that there is no modeling of green positions, but the modeling of positions of the split times. Here various optimization criteria are possible. (Krejci, L., 2011)

6. EVOLUATION OF THE ANALYSIS IN A REAL ENVIRONMENT

Analysis of light signal device should be focused on the change between intervals. If there were some changes at various crossroads some light signals occur which create a risk of an accident. Traffic accidents are extraordinary events that affect not only the correct function of the critical infrastructure. For this reason, it is necessary to pursue this issue. On figure 3 it is shown a real case how the light-signaling device can be dangerous.

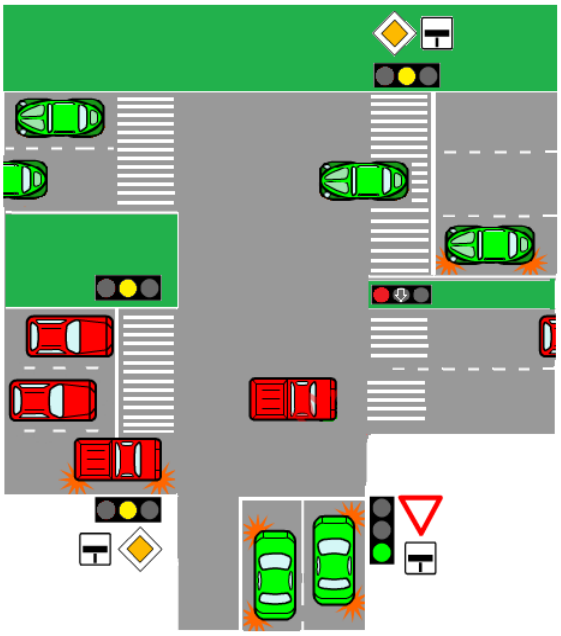

Figure 3 Illustrated real signals from case studies [author]

The picture shows the individual signals from each side of the crossroad. Each semaphore is shown according to the real analysis. From the picture, it is clear that in cases where we cannot safely stop and drive through the crossroad on a yellow light signal it could actually lead to a traffic accident.

Because of the fact that the individual crossroads are different, it is necessary to set the risky crossroads individually. When assessing the above-mentioned crossroads we concluded that our proposed measures are not too expensive and can be dispensed with and without structural modifications.

Corrective solution is aimed at complementing the programming language when it comes to its completion. We add condition that compares individual states of light signaling devices. Using the comparison, we prevent the situation shown in figure 3

7. CONCLUSION

S Lights signaling devices are classified among safety components on the roads. They ensure both safety and continuity on the land road. Taking into account today traffic density, we cannot avoid these devices. It would be chaos on the roads. Statistical data of the number of accidents would quickly increase.

At present, we can say that finding of a light signaling device is not a problem. From the safety perspective, we can permanently innovate something. It is a question if there is no need to start to build the safety from the ground.

The density of traffic is still growing. Traffic lights cannot be accelerated. The only one offered solution is to program the minimum spacing between switching of light signals. Consequently, we call such crossroads risky ones. Not only has that, in the event of a traffic accident the state had to pay money the participants. In the worst possible cases, fatal injuries occur here. At these events, we can also be a direct participant or a close person of one of the participants.

To increase safety we must implement conditions for the individual directions to avoid the shown risky situations. Case situation is shown in figure 3. To be able to minimize such situations, we have to individually assess each crossroad based on the statistics. Taking into account the statistical data of the given crossroad, we have to focus on offences like running on the red light so called disrespecting right of way. After picking up the data, we can analyze the obtained information and we can analyze other risky crossroads with lights. Gradually, we can apply our proposed solutions in terms of programming. The result will not only minimize the number of accidents at crossroads with light signaling devices but provide the greater safety as well.

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