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Activities Aimed at Improving Road Traffic Safety at Night

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ABSTRACT

Nighttime traffic risks have been thoroughly analyzed in the current work indicating the activities to be implemented to reduce the number of night accidents. It is shown that the normative standards for the brightness of street lighting in Armenia are rather low as compared to other countries. The types of luminaires providing the street lighting and their layout have to be assessed. Some measures have been presented to improve the driver's field of vision, the defects of widely used luminaires and the consequent dangers have been clarified, as well as a safe road lighting scheme has been suggested.

Introduction

Traffic accidents typically occur in a variety of conflict situations that are well studied and do not need to be revised. Traffic accidents happening at night time pose a serious problem, since the mentioned conflict situations are associated with limited visibility, fatigue and even drowsiness of the drivers whose eyesight is getting impaired at the dusk and in the darkness. Usually, the night traffic makes only 15-20 % of the total daily traffic; however accidents occurring in conditions of such low traffic intensity are almost half of the average daily accidents. Besides, evening twilight is more dangerous, during which about 65 % of traffic accidents happen, while in the morning it makes up to 25 %. The statistical analysis of night accidents indicates that their consequences exceed those of daytime data by 30 %-40 % regarding both the injured people and deaths. So, driving at night time is more dangerous (about in 2.5-3.5 times) than during the day, and the probability of lethal outcome increases up to 10 times (https://mash-xxl.info/info/574543/). The percentage of night accidents in residential settlements is a bit lower than that of on the roads outside the settlements. Considering the night hours, the main conflict situations occur in vehicle-person collisions.

Materials and methods

The growth of traffic accidents at night time against the daytime is accounted not only for insufficient vision, but also for a number of objective factors: fatigue, visual problems, distorted perception of distance, colour changes in different subjects, optical illusions, etc. However, in all

cases, the main problem is insufficient field of vision in all directions of the night traffic. As we can see, extensive activities need to be implemented to reduce the number of night traffic accidents, which should include all field-related organizations and individuals. Artificial street lighting (both traffic lights and located street lights) can never be compared with the amount of light provided by the sun, which is about 10 000 lux, and the brightness is 8000 kD/m^2.

Different countries have different normative standards for night lighting of their roads, where the brightness varies in the range of 1.6 - 4.2 kD/m^2; moreover, the brightness can vary from minimum to maximum 1:1.3 in dry weather and up to 1: 1.6 in rainy weather. It should be mentioned that the normative indicators of night lighting are stated by the Ministry of Urban Development of the RA, upon the Decree № 82, 06.08.1996 (Construction Code of the RA, Decree № 82, 06.08.1996).

The study of the mentioned document shows that the defined indicators revise the normative indicators that have been operating in the USSR for years and are still operating in Russian Federation. For comparison, we can mention that in Armenia, the norm for brightness is 1.6 kD/m^2, in many European countries it ranges from 2 to 2.6 kW/m^2, while in the USA it amounts to 4.2 kW/m^2.

It's not accidental that in Armenia the dominant part of traffic accidents are night accidents, and as a matter of fact, most of all have tragic consequences because on the one hand, the norms are weak, and on the other hand, those norms are not even ensured. Along with street lighting the road cover type, markings made on them, the types of road signs and installation methods, the dye-stuff used for marking should be taken into account. The light fittings used for the street lighting, the ways of their installation, the use of light effects in the roadside areas and on the advertising boards are worth special evaluation. Application of LED lights and the presence of timers significantly facilitate the driver's work; anyhow new problems appear in the dark hours of the day.

The brightness of LED lights considerably exceeds the brightness of the lights used before. In the presented diagram (Figure 1), the driver has the signals of (a) and (b) traffic lights in his field of vision in the daylight hours, so he can choose an optimal mode of movement only in the daylight hours, since at this time the driver clearly identifies (a) and (b) traffic lights and the distance between them.

The situation is rather different at night time, especially during the rain. In this case, the driver approaching the (a) traffic light can see both (a) and (b) traffic lights in the dark, but very often he can't figure out which on-off light signal he is concerned with until he is very near to the (a) traffic light. Orientation at the last moment and drastic actions can cause emergency situations and also traffic accidents. A number of such driving sites can be mentioned in Yerevan, e.g. Tbilisi highway. However, we can eliminate this confusing situation due to some technical changes. Let's consider the diagram of traffic light change with horizontal layout.

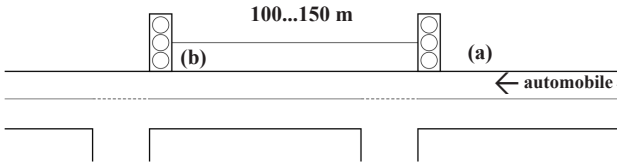

Figure 1. Traffic lightsplaced at a distance of 100 -150m (*composed by the authors*).

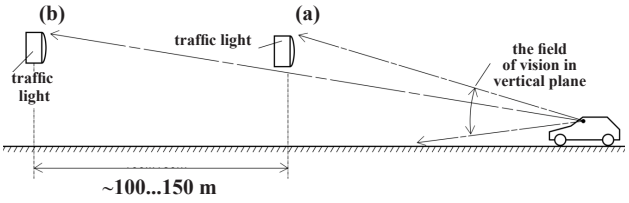

Figure 2. Traffic lights appeared in the driver's field of vision in vertical plane (*composed by the authors*).

Figure 2 shows that both (a) and (b) traffic lights are located in the driver's field of vision. Let's consider the proposed changing diagram for removing the (b) traffic light from the driver's field of vision (Figure 3).

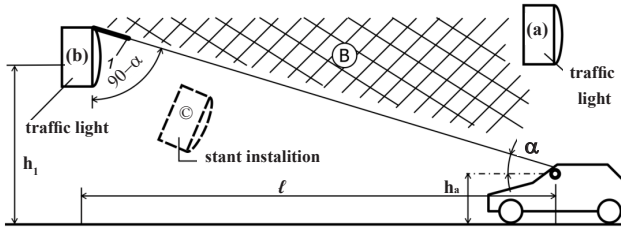

Figure 3. The diagram of removing the (b) traffic light from the driver's field of vision (*composed by the authors*).

LED lamps usually have a fairly narrow angular range of light radiation. Therefore, it'll be better to place a cover on the traffic light bent at a certain angle, moreover the bending angle of the cover depends on the dimensions of the environment, which will intervene the light dispersion over the darkened sector (B). It's also possible to use the (c) variant, where only the traffic light bents at a certain angle providing better visual opportunity within the (a) – (b) range. The size of *a* angle can be calculated for each point in the following way:

$$tga = \frac{h_l - h_a}{l},$$

where h_l is the height of the traffic light from the road, h_a is the average height of the driver's eye from the road, l is the distance projection between the driver's eye and the traffic light, where the traffic light should be seen.

Road lighting significantly changes depending on what cover it has. It is a fact that asphalt roads are poorly lightened, especially when it rains. The appearance of the thinnest snow layer on the road is enough to create an ideal lighting. From this point of view, concrete roads are in better position. So, it becomes obvious that it's desirable to have such a cover on the road which will provide the needed light reflection. White line marks are very noticeable on the asphalt roads and yellow line marks - on the concrete roads. It should be always noted that if the driver doesn't clearly distinguish the road from the roadside due to the road lighting, then it'll always bring to dangerous consequences.

Results and discussions

Recently, the most widely used modern lighting devices have significantly affected the safety of night traffic (https://works.doklad.ru/view/5FkryDSLQTI.html). When we just walk through the streets of any settlement in the evening, we can see road sections illuminated with bright lights. Besides, many luminaires are placed in such a way that the powerful ray of the light is directed straight to the moving car (in gas stations, cafes and other complexes). Of course, the driver's eye gives a corresponding biological reaction: the eye pupil gets narrow, as a result of which the driver hardly makes out the road situation. There can be even situations when the monitor placed on the road emits such a bright light over its surface which immediately blinds the driver (for example, at the top of "Lambada" crossroad).

Such problems can be solved by eliminating the shortcomings enhanced as a result of regular professional monitoring. The studies have shown that luminaires have dangerous disadvantages. The fact is that widely used luminaires (Figure 5) are very suitable for night lighting of the yards and recreation areas, but not for streets and roads.

Columns equipped with such lamps, placed along the road at l distance from each other, provide the road with very bright lighting points in case when brightness of the road is ten times lower (Figure 4).

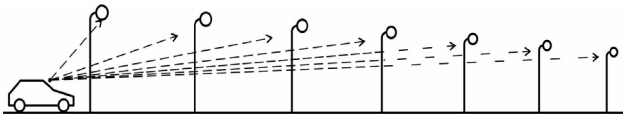

Figure 4. The effect of incorrectly selected road lights on the driver's eyes (*composed by the authors*).

Partial blindness caused by such luminaires is very noticeable during the rain and completely disappears during the snowfall. The mentioned unfavorable situation is connected with the fact that the lamp (Figure 5) emits the light with an aperture of about 160-170^0, in case when we need to have what is depicted in Figure 6 to illuminate the street.

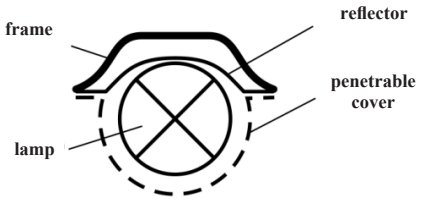

Figure 5. Exterior lighting lamps (*composed by the authors*).

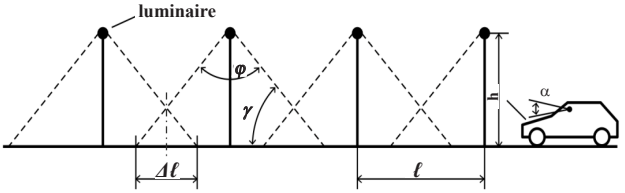

Figure 6. Proper road lighting diagram (*composed by the authors*).

As we can see from the diagram, the luminaires don't appear in the driver's field of vision; therefore his eyes react only to the road surface lighting. The mentioned was also proved through an experimental method. As shown in Figure 6, the car is parked on the right side of the illuminated street with the nearby lights on. Visibility of the sidewalk was assessed when there was a traffic flow in the opposite lane (lights on) and when it was absent.

From the driver's seat, per the eye position, photo was taken for both cases. Then the driver compared the image of the photo with the image he perceived, and as a result, it was found out that there is a significant difference. Naturally, the difference is due to the physiological properties of the eye associated with the accommodation of the lens of the eye.

Thus, for correct and safe lighting along the longitudinal direction of the road, it's necessary that the lighting emits only at a certain φ angle, the magnitude of which can be calculated through the following formula: $\varphi = 2\,(90\text{-}\gamma)$, where:

$$tg\gamma = h / \left(\frac{l}{2} + \frac{\Delta l}{2} \right),$$

where Δl is the sector, which is illuminated by two adjacent luminaires at the same time, l is the distance between the two adjacent luminaires, h is the distance between the luminaire and road cover, γ is the angle formed by the light emitted from the road cover and luminaire. So, we can accept that:

$$\Delta l = \frac{l}{3},$$

therefore:

$$tg\gamma = \frac{h}{\left(\frac{l}{2} + \frac{\Delta l}{6} \right)} = h / \frac{2}{3} l.$$

Conclusion

Thus, the correct choice of the road surface type and its line marks, the road signs and their installation places, the types of luminaires and the ways of their installation, as well as the accurate use of billboards and provision of proper night lighting in the roads will enable to significantly increase the safety of night traffic.The development and application of technical measures that could block the car driving (especially at night) for tired (drowsy) drivers will also contribute to the safety increase. It is also recommended that novice drivers with less than a year of experience (or those having 5000 km run) shouldn't drive at night.

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