# LUMINANCE CONTRAST IN ROAD LIGHTING

Władysław Golik
Technical University of Poznań
Poland

Małgorzata Górczewska
Technical University of Poznań
Poland

## ABSTRACT

Seeing in road lighting is a complex function of many factors widely described in the professional literature. One of the basic criteria of providing proper road safety is the possibility of sufficiently fast noticing an obstacle which is on the road. Its visibility is determined mainly by a luminance level and a luminance contrast. A well designed lighting device can provide its good visibility. The paper presents research results of the standard obstacle contrast proper for its reliable noticing on the road in the typical background luminance range, i.e. 0.5 - 2.5 cd/m$^2$ .

## INTRODUCTION

### Obstacle visibility in an illuminated street

Qualitative factors of street illumination are determined in the CIE Report No12.2 [2]. Satisfying these demands while designing street lighting does not always provide proper obstacle visibility on the road [1].The obstacle will be visible in an illuminated street only if its contrast Co with the surface of an illuminated street will be greather than the threshold contrast Cref.

$$|C_o| > |C_{ref}|$$

With street illumination, the obstacle should be noticed as dark in the brighter street background, i.e. the contrast Cref and Co should be of a negative value (Cref and Co < 0).For most contemporary cars the obstacle of the dimensions 0.2 * 0.2m is critical. If such an obstacle is not noticed on the road on time it can cause a very dangerous accident. Obstacles which are on the road can be characterized by different

properties of light reflection. Those, whose luminance coefficient is close to average luminance coefficient of the road, will be critical. The obstacle which reflects light in the diffuse way with the reflection coefficient of 0.2 will satisfy this condition.Taking it into consideration, the obstacle of the dimensions 0.2 * 0.2 m reflecting light in the diffuse way with the reflection coefficient 0.2, is assumed as the standard obstacle for evaluating contrast rendition of an obstacle in an illuminated street.
The contrast of the standard obstacle in an illuminated street is not constant. Its value, as it results from the formula:

$$C_o = [ (L_o - L_s) / L_s ]$$

depends on street surface luminance $L_s$ and on the value of vertical illumination $E_v$ corresponding to the vehicle movement direction $L_o = f(E_v)$ in a given place of the street. Values of both these quantities depend on light distribution of luminaires and the kind of street lighting system (single-sided, central, opposite and staggered lighting, luminaire overhang, spacing between luminaires, street width, and the height of the luminaire) and moreover, street luminance depends on reflection properties of the road surface (class R and value $q_o$).
Finding a way of designing a lighting system which gives good obstacle visibility in the street and determining factors which influence improvement of visibility conditions in an illuminated street requires that the value of the obstacles threshold contrast $C_{ref}$ should be known for the background luminance range 0.5 - 2.5 cd/m$^2$.

## EXPERIMENT AND EXPERIMENTAL PROCEDURE

### The stand for measuring obstacle contrast with the road

Determining the value of Cref in real conditions is inconvenient. Therefore, a laboratory road model with obstacles has been elaborated and made, it is in Fig. 1.

Angular dimensions of the road which is seen in front of the observer in the shape of a bright field in the dark background are matched so that they could refer to the picture of real road observed by the car driver.

Two holes of angular dimensions referring to the picture of the standard obstacle from the distance of 60 m were placed side by side on the width of

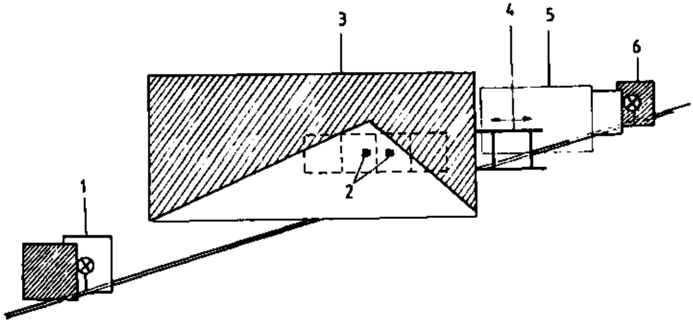


**Figure 1** Experimental stand for investigating luminance threshold contrast: 1,6-light sources, 2 - holes (obstacles), 3 - road model, 4 - movable filters, 5-opal shield

the road lane which refers to the movement direction. This distance was matched taking into consideration a driver's possible response connected with noticing the obstacle. Both the holes were covered with a movable screen, which was practically invisible to the observers. There was a proper completing road fragment in order not to change adaptation conditions. An opal diffusing shield was placed at the back of the holes, which gave obstacle luminance. There was a movable filter trolley between this shield and the holes which enabled moving the filters to one of the holes making the obstacle or beyond the holes.
The luminance of the model of the road and the obstacle (opal shield) was being changed by varying source distance from illuminated objects and, within a small range, by changing supply voltge. All the sources were connected parallely in order to avoid colour shift at the voltage control.

Luminance measurements were made with the LMT 1006 luminance meter.

**Contrast research results with the observers.**

The preliminary measurement series, which tested suitability of the designed stand for investigating threshold contrast, was taken in a group of five experienced observers. Each of them, after a period of preliminary adaptation, was making a series of training investigations. Next, another measurement series was conducted - ten for each background luminance level, i.e. 0.5, 1.0, 1.5, 2.0, 2.5, cd/m² . In these investigations, each of the observers regulated obstacle luminance himself until the moment he could distinguish it from the background. The results of the investigations obtained by this method are presented in Fig.2.

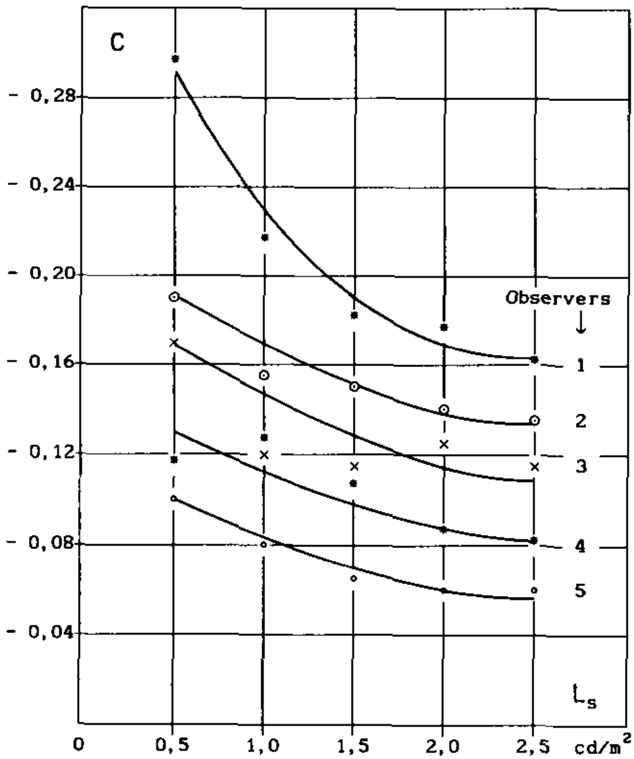


**Figure 2** Curves of luminance threshold contrast C as a function of road luminance Ls for five observers who change obstacle contrast themselves

For each of the observers, there are set measurement points and curves of threshold contrast changes as a function of road luminance referring to them. It is noticable that all the curves have very similar courses, however their values are substantially different. These differences cannot be explained only by various contrast sensitivities of the observer s eyes. We should rather assume that each of them, setting the threshold luminance level, was led by different criteria, i.e. from the threshold of visibility and invisibility to reliable noticing the obstacle.

Including these preliminary experiments, a new way of making investigations was prepared. The change of the contrast of the obstacle with the background was made a non-continuous way by introducing grey filters. The observer was to identify one of the obstacles within 4 seconds. For each road luminance level, observations were made, changing successively the filters. It was assumed that a contrast level is suitable for a given observer when at least nine correct answers were obtained per ten trials. In order to eliminate self-sugestion in evaluating obstacle visibility, the filter was being removed, which gave zero contrast.

Twenty people took part in the research, i.e. sixteen people aged 22 - 23 years old and four people aged 40 - 50 years old. No significant differences were found in the obtained results by both the groups of experienced observers. The results are presented in Fig.3.

For different contrast values of the obstacle with the background, the diagrams show the numbers of observers for whom the obstacle was seen well (+), seen at the visibility threshold (+/-), and not seen (-). It must be stressed that according to the observers uniform opinion, the results obtained at the visibility threshold, denoted as (+/-), would not let identify the obstacle. It is a great facilitation, in the laboratory conditions, that the obstacle is observed statically: it appears in one of the expected places, whereas during observing the road by the driver, there are many factors absorbing attention, therefore noticing the obstacle is more difficult. This is the reason why only those evaluations which found the obstacle visibility as good (+) should be included during determining a suitable, minimum contrast value of the obstacle with the background for the design needs. Such evaluation results are presented in Fig.4 for at least 50% and 90% observers noticing the obstacle, respectively.

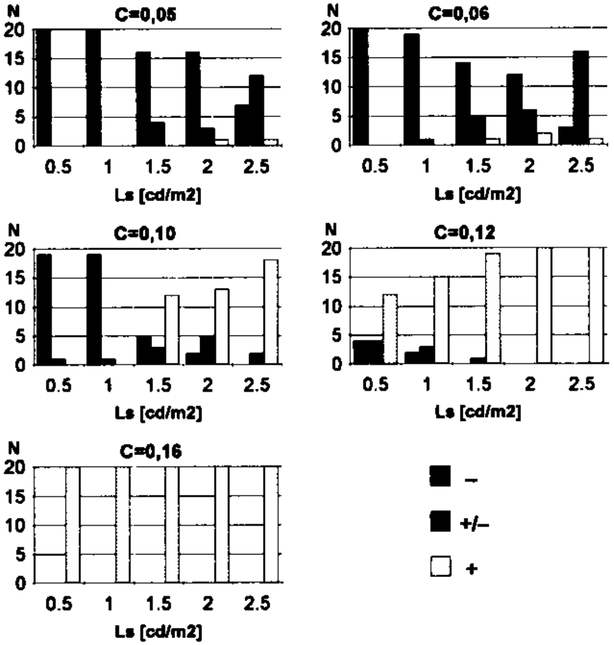


**Figure 3** Evaluation of obstacle visibility as a function of road luminance Ls for the contrast C according to the scale: (+) visible, (+/-) visibility threshold, (-) invisible

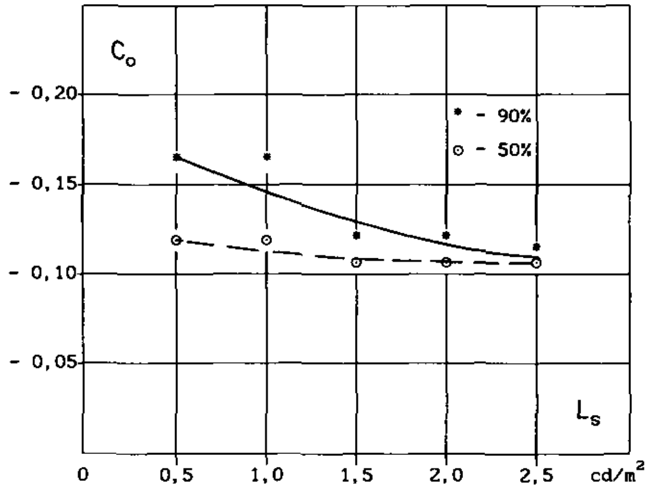


**Figure 4** Contrast values Co of the obstacle with the background luminance Ls, suitable for noticing an obstacle of the dimensions 0.2 * 0.2m from the distance 60 m for at least 50% and 90% observers (there is also an *anticipated course of the curve Cref = f(Ls))*

## CONCLUSIONS

As we can see, assuming a 50% threshold for the analyzed road luminance range, the proper contrast is at the level of Cref = 0.12. Taking the higher, 90% threshold causes that for lower luminnance levels, i.e. 0.5 - 1.0 $cd/m^2$ , we should assume higher values of luminance threshold contrast, that is Cref=0,16

Of course, the assumed non-continuous contrast change does not allow to determine precisely an accurate value of threshold contrast for each of the investigated road luminance levels. However, it seems that the values determined in this way are sufficient to evaluate obstacle visibility conditions on the road.

## REFERENCES


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