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Assessment of the state of pedestrian crossing lighting on the basis of field measurements of luminance

***Abstract**. Producing a proper level of contrast of a human figure with the background on pedestrian crossing is an indispensable condition for creating possibilities of noticing a pedestrian by a driver of a vehicle approaching the crossing. The paper presents detailed results of luminance measurements on the pedestrian crossing illuminated by means of three lighting solutions. On the basis of the obtained results of luminance and luminance contrast, effects of lighting of a pedestrian figure have been compared.*

Streszczenie.** Wytworzenie odpowiednio wysokiego poziomu kontrastu sylwetki człowieka z tłem na przejściu dla pieszych jest warunkiem niezbędnym do stworzenia możliwości jej rozpoznania przez kierowcę pojazdu zbliżającego się do przejścia dla pieszych. W artykule zaprezentowano szczegółowe wyniki pomiarów luminancji na oświetlonym za pomocą trzech rozwiązań oświetleniowych przejściu dla pieszych. Na podstawie otrzymanych wyników luminancji i kontrastu luminancji porównano efekty oświetlenia sylwetki pieszego.* ***(Ocena stanu oświetlenia przejścia dla pieszych na podstawie terenowych pomiarów luminancji).

Słowa kluczowe: pieszy, luminancja, kontrast, oświetlenie przejść dla pieszych, oświetlenie uliczne.
Keywords: pedestrian, luminance, contrast, lighting of pedestrian crossings, street lighting.

Introduction

Application of additional light frames significantly increases lighting conditions both for a pedestrian and for a driver of a vehicle approaching the crossing. Assessment of the state of lighting can be conducted with the use of luminous flux density parameter [1]. However, on the basis of the criterion of luminous flux density, one cannot draw conclusions on the contrast of a human figure against its background – luminance of pedestrian crossing surroundings is not accounted for. The parameter of luminance contrast is the best factor determining observation conditions of a pedestrian by a vehicle driver. In practice, this should mean application of luminance method to the lighting assessment of a human figure on pedestrian crossing. In the present paper, for assessment of possibilities of application of particular light frames, the assessment model of luminance and luminance contrast of a human figure against its background is used [2, 3, 4]. An effective way of assessment of lighting properties used on pedestrian crossing is by means of field researches of luminance distribution on pedestrian figures.

Research objective

The paper presents results of luminance measurements of a human figure for three lighting situations. The first situation refers to pedestrian crossing lighting by means of light frames, the second and third situation refer to pedestrian crossing lighting by means of additional frames dedicated to pedestrian crossing lighting [5, 6].

The pedestrian crossing nominated for the present research is in Warsaw at the junction of Walerego Sławka Str. and Karola Adamieckiego Str. in Ursus district. The case presents lighting of pedestrian crossing by means of street light frames in a single sided arrangement with the spacing of 26m, along a two-way single carriageway with one lane for each direction. The width of the roadway equals 7m. Street light posts are situated asymmetrically with regard to the crossing, which is presented in figure 1 (indicated by a dot). From the side of Konińska Str. the distance between the axis of the crossing and the light frame equals 6,75m, whereas in the direction of Bohaterów Warszawy Str – 19,25m. Geometry of measurement model for luminance of a pedestrian figure has been described in detail in [2, 3, 4]. In the case of measurements mentioned below, two observation directions of pedestrian crossings have been assumed from the distance of 60m.

Fig. 1. Placement of street lighting with regard to pedestrian crossing with indicated directions of measurement [7]

Fig. 2. Picture of the street illuminated by means of light frames OUS [9]

The observer is situated within the axis of each traffic lane at the height of 1,5m above the roadway and is observing 8 objects (pedestrian figures, covered with a fabric of reflection coefficient ρ=0,2) situated within crosswise axis of the crossing. The objects are indicated with numbers form 1 to 8, starting from the left. Objects of numbers 1 and 8 have been situated at the distance of 0,5m from the edge of the roadway – in the waiting area.

Measurements have been conducted by means of LMK Mobile Advanced Imaging Photometer [8]. Luminance has been measured for each object on the whole surface of the object (target luminance L_T) and its surroundings (background luminance L_B). On the basis of the measured values, luminance contrast of the target against its background has been measured.

Lighting of pedestrian crossing by means of street light frames

First, the case of lighting of pedestrian crossing area by means of street light frames shall be presented. The street is illuminated by means of light frames OUS [9] with sodium light source of the power of 150W. The street light frames are mounted at the height of 10m on posts ŻN-10 (fig. 2). It should be mentioned that in Polish conditions, the street lighting is the most common means of lighting pedestrian crossings.

Figures 3 and 4 below, present measurement results in the form of luminance images obtained for lighting of test objects on pedestrian crossing by means of street light frames.

Fig. 3. Luminance measurement of objects form the first observation direction (logarithmic scale log_2, unit cd/m^2)

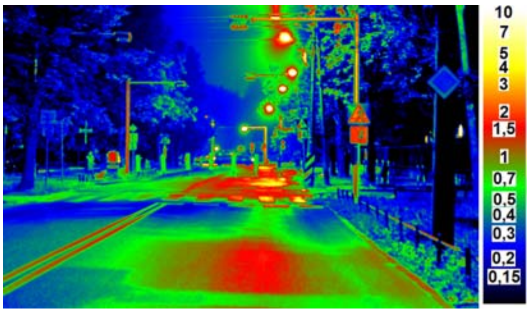

Fig. 4. Luminance measurement of objects from the second observation direction (logarithmic scale log_2, unit cd/m^2)

Figures 5 and 6 show graphic representation of the obtained results of luminance measurement and calculated values of contrast for two observation directions.

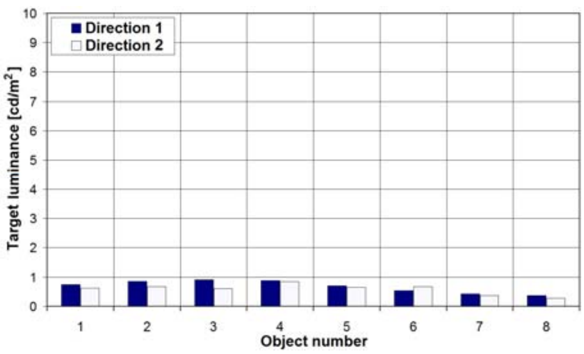

Fig. 5. Results of target luminance measurements for two observation directions in the case of lighting by means of street light frames

Pedestrian crossing lighting by means of additional light frames type

The second case presents measurement results of target luminance on pedestrian crossing illuminated by means of temporarily installed additional light frames type 1 with metal-halide light source of the power of 150W. Measurement was conducted with the street lighting switched on. Light frames type 1 characterize of asymmetrical light beam distribution, adjusted to lighting of pedestrian crossing area [5]. Two light frames in a staggered arrangement have been used. They have been placed in accordance with the producer's requirements at the distance of 3m from the axis of pedestrian crossing, and 0,5m from the edge of the road at the height of 4m above the plane of the roadway (fig. 7).

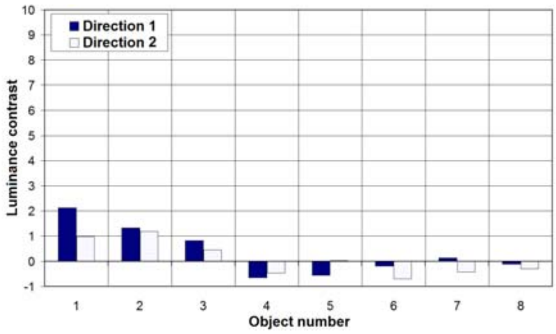

Fig. 6. Calculated value of luminance contrast of target against background for two observation directions in the case of lighting by means of street light frames

Fig. 7. Light frames type 1 temporarily installed on pedestrian crossing

Figures 8 and 9 present luminance images of objects illuminated by means of light frames type 1 on pedestrian crossing.

Fig. 8. Luminance measurement of objects form the first observation direction (logarithmic scale log_2, unit cd/m^2) in the case of pedestrian crossing lighting by means of light frames type 1

Figure 10 shows graphic representation of the obtained results of luminance of test objects. Figure 11 presents the value of luminance contrast of objects against background.

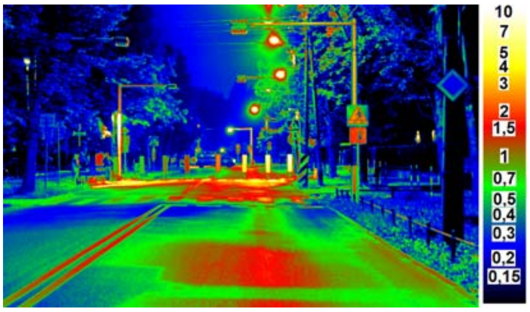

Fig. 9. Luminance measurement of objects from the second observation direction (logarithmic scale log_2, unit cd/m^2) in the case of pedestrian crossing lighting by means of light frames type 1

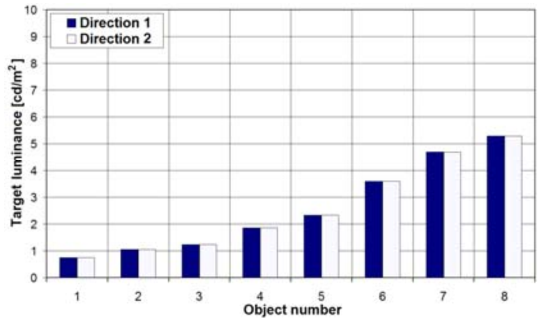

Fig. 10. Measurement results of target luminance for two observation directions in the case of lighting by means of light frames type 1

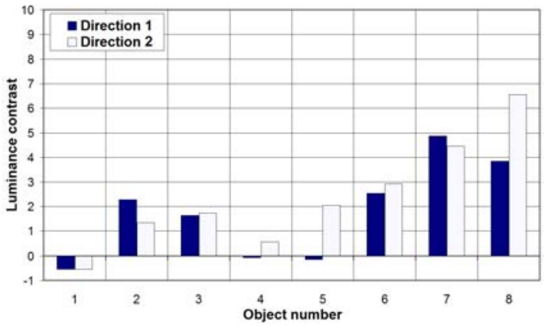

Fig. 11. Calculated value of luminance contrast of target against background for two observation directions in the case of lighting by means of light frames type 1

Fig. 12. Light frames type 2 permanently installed on pedestrian crossing

Pedestrian crossing lighting by means of additional light frames type 2

The next lighting situation refers to the case of pedestrian crossing lighting by means of additional light frames type 2 presented in figure 12. The measurement was conducted with the street lighting switched on. Additional light frames are recommended by their producer for pedestrian crossing lighting [6]. They are permanently installed on pedestrian crossing, in geometrical system that is in accordance with the producer's requirements [6]. The applied light frame characterizes of asymmetrical light beam distribution.

Figures 13 and 14 present luminance images of objects illuminated by means of light frames type 2 on pedestrian crossing.

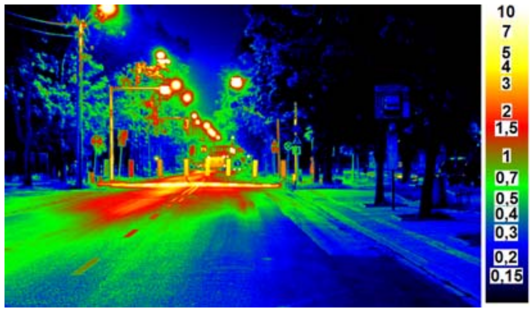

Fig. 13. Luminance measurement of objects form the first observation direction (logarithmic scale log_2, unit cd/m^2) in the case of pedestrian crossing lighting by means of light frames type 2

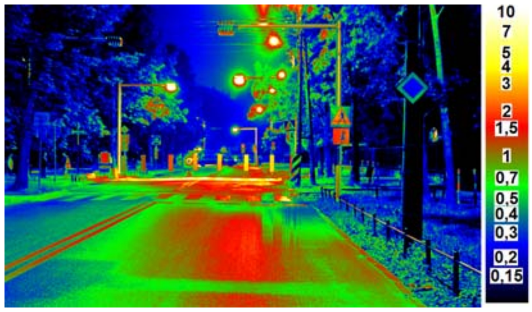

Fig. 14. Luminance measurement of objects from the second observation direction (logarithmic scale log_2, unit cd/m^2) in the case of pedestrian crossing lighting by means of light frames type 2

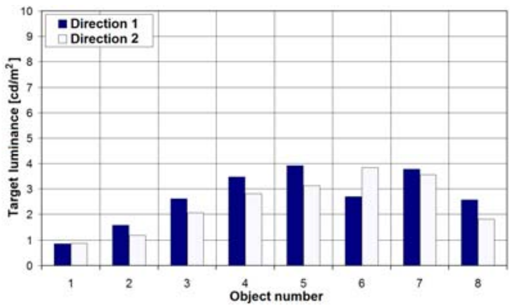

Fig. 15. Target luminance values obtained in the case of lighting by means of additional frames type 2 for two observation directions

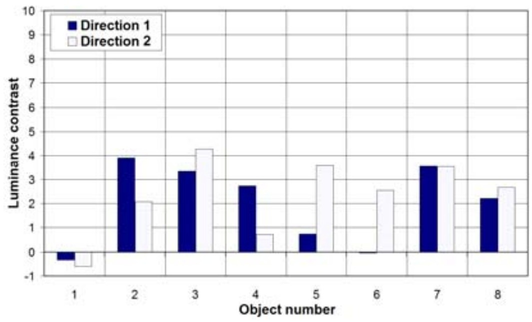

Fig. 16. Luminance contrasts of target against background in the case of lighting by means of additional light frames type 2 for two observation directions

Figure 15 presents luminance values of particular objects situated on the crosswise axis of the crossing for two observation directions.
Figure 16 presents the obtained values of contrast of a human figure against its background.

Conclusions

As it follows from the conducted researches and obtained results of photometric measurements, street light frames installed are not capable of ensuring proper observation conditions of a pedestrian figure on the crossing from the perspective of a vehicle driver. Luminance values obtained (fig. 5), signify the disadvantageous lighting of objects (pedestrian figures), situated in the area of pedestrian crossing. Particularly disadvantageous is obtaining the low values of luminance contrast of target against background, situated within the direction of vehicle traffic (objects no. 6 and 7 in fig. 6). It has been indicated that within the area of pedestrian crossing there is a disadvantageous situation of polarization change of luminance contrast from positive into negative. This situation may, in the extreme case, lead to producing the contrast of the value close to zero (object no. 5 in figure 6), which in turn may cause lack of possibility of noticing a pedestrian on the crossing by a vehicle driver.

Light frames type 1 that are temporarily mounted, have an advantageous influence on improvement of luminance of a human figure that is on the roadway within the waiting area, particularly for the direction compatible with the road traffic direction (objects from 4 to 8). As it results from figure 10, the values of target luminance increase systematically and the highest values are obtained within the waiting area – object no.8. It should also be mentioned that the applied light frames were temporarily mounted and did not achieve full lighting parameters. Temporary installation made it difficult to direct the light beam precisely in the assumed direction of emission. What is worth attention is the fact that the light frame type 1 obtained significantly higher values of luminance than those obtained by street light frames with a lower use of electric energy. Application of metal-halide light source of the power of 150W together with a properly shaped reflector, ensures comparative values of luminance in relation to the street solution with installed source of power of 250W.

The technical solution applied consisting in installation of light frames type 2 has a significantly advantageous influence on improvement of lighting conditions on pedestrian crossing within roadway area. Realized luminance distribution of the light frame, however, does not allow for additional lighting of the object that is situated in the waiting area (object no. 8 in figure 15) on the level of luminance values obtained for light frames type 1 (object no. 8 in figure 10).
For objects no. 4 and 5 in figures 11 and 16, despite the high values of target luminance, a sudden fall of luminance contrast can be noticed, which is caused by high value of background luminance. This factor has a disadvantageous influence on the lighting situation and such situations should be eliminated.

The proposed method of assessment accounts for luminance parameters. The values of luminance obtained on test objects – pedestrian figure, directly indicate the need for implementation of solutions improving the state of pedestrian crossing lighting.

What is worth attention is the lighting of pedestrian crossings by means of additional light frames type 1 or type 2. Thanks to the application of dedicated light frames in a staggered arrangement, the value of luminance of a pedestrian figure observed by a driver of an approaching vehicle, significantly increases. High levels of contrast are created, which are indispensable for recognition of a pedestrian figure dressed in clothes of low reflection coefficient (e.g. ρ=0,2).

The proposal of approaching the problem presented in the paper makes it possible to determine luminance contrast of a pedestrian figure on pedestrian crossing and within the waiting area. Luminance measurement accounts for the existence of a driver – observer, as well as geometry of measurement connected with this figure [2, 3, 4].

Results presented in the paper constitute an introduction to conducting further research. The present author in the foreseeable future plans presentations of field research results conducted on a bigger number of nominated pedestrian crossings equipped with various lighting systems. The objective of future field researches will be determining the scope of changeability of contrast value for the applied lighting solutions on pedestrian crossings in real conditions.

Photometric research of road infrastructure, including pedestrian crossings, may contribute to the improvement of safety of unprotected participants of road traffic.

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LITERATURE

[1] Standard *DIN 67523-1/2:2010:* Lighting of pedestrian crossings (sign 293 StVO) with additional lighting
[2] Tomczuk P., Assessment model of luminance contrast of pedestrian figure against background on pedestrian crossing, *Electrical Review, R. 88 NR 3a/2012 p.104-107 SIGMA-NOT*
[3] Tomczuk, P., Pedestrian safety – luminance measurements on pedestrian crossing, *Research papers of Warsaw University of Technology, Transport, Researches on Transport Means and Systems, Research Bulletin no. 80, pp.117-135 Oficyna Wydawnicza Politechniki Warszawskiej, Warsaw 2012*
[4] Tomczuk P., Formal requirements basis of illuminance parameters concerning pedestrian crossing lighting, *Monographs of the Maintenance System Unit, Polish Academy of Sciences, Committee on Machine Building Maintenance, Problems of Maintenance of Sustainable Technological Systems*, *Volume IV, Automotive Engineering and Vehicle safety Engineering*, pp. 165-186, Kielce University of Technology, Kielce 2012
[5] Producer of lighting frames Thorn IVS, *www.thornlighting.p*
[6] Producer of lighting frames Calypso Zebra, *www.schreder.pl*
[7] *Google* digital map
[8] Catalogue data LMK Mobile Advanced, *www.technoteam.de*
[9] Producer of lighting frames, *www.brilux.pl*

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