Influence of flux reduction system on environment, visibility and safety of drivers

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ABSTRACT

Last years, energy savings in lighting became a more and more important subject. As a matter of fact, cities, regions and most generally people who are in charge of public lighting try to perform energy savings but what about user considerations? In other words, there are really few experimentations concerning the evaluation of users towards the use of equipment for the reduction of luminous flux. This paper presents experimentation with observers, who were asked to assess the visibility of targets on the road surface under different levels of illumination (promoted by lower energy use). The first experimentation has taken place at the University of Sao Paulo Campus, IEE_USP, Brazil and this paper describes another one, which takes place in a private site in France. In both places, a luminous flux reduction system is installed. These experimentations intend to show how luminous flux reductions influence people behavior and to approximate minimum visibility levels for a safety and comfort purpose. In the presented conditions, a visibility level of 4 was considered sufficient to have a good recognition of objects (visibility) in suburban roads with small traffic and good weather.

INTRODUCTION

Last years, the problem of energy on Earth became more and more important. The crisis of energy in America, at the present time, confirmed that energy is not endless and it gives lots of subjects of thoughts for us. All the different parties involved in public lighting (cities, regions, companies...) intend now to do energy savings. One of the solutions is to use dynamic public illumination, which allows a reduction of energy consummation and maintenance costs. However there are really few experimentations [1] concerning the evaluation (feelings and reactions) of users towards lighting reduction and environmental modifications that results. As a matter of fact, it is a good idea to reduce luminous flux but what is happening on safety viewpoint.

This paper presents experimentation concerning the observers' appraisal of road target visibility set on the road surface. Rate appraisal evaluation was made with hemispherical target under different levels of illumination. The two main goals of this study are firstly, to evaluate a minimum visibility level (using the Adrian model [2]) for a safety and comfort purpose, and secondly to define characteristics of an installation for a safe reduction of luminous flux.

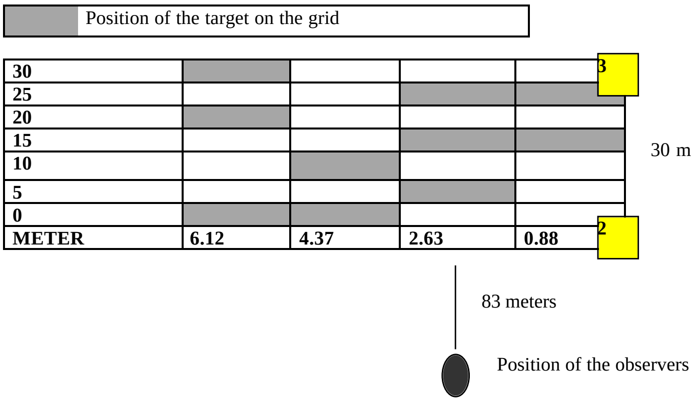
PRESENTATION OF THE EXPERIMENT

This experimentation has taken place at the CETE Normandie-Centre in Rouen, France on our test site. The luminous flux reduction system has been installed there and controls the flux of five luminaries. At the pavement level, between the luminaries 2 and 3, a grid of 28 points was located for the evaluations.

The test track at the CETE Normandie-Centre includes a roadway, 7 m wide, covered with a R1 type coating, with a controlled Qo of 0.10. It is lit with five luminaries (150 W high-pressure sodium lamps) whose mounting height,

Figure 1. Visibility appraisal of hemispherical targets with flux at 100% (on the left) and at 50% (on the right) (CETE Normandie-Centre).

Figure 2: Position of the target on the grid between luminaries 2 and 3.



spacing and overhang can be adapted. To get an homogenous lighting installation, which is for us one of the conditions for dimming, we chose one mounting height of 8 m and one spacing of 30 m. This installation has a longitudinal uniformity of 0.75 and a transversal uniformity of 0.51, which is quite good. We have done some simulation that shows that with (100, 75, 50 and 25) % of the luminous flux, the range of visibility levels from 2 to 11 will be covered using this layout.

The target can be placed on 28 points of a grid regularly spaced between two consecutive luminaries. We only used 10 positions of this grid randomly chosen to cover all visibility levels of targets.

The target is a ball of 20 cm diameter with surface reflection factor of 0.2 (figure 1). Because there were only five luminaries with flux reduction systems, and in order to keep the same lighting levels in the background, a supplementary luminary was added to give the observer similar luminous surroundings. The origin of the grid (0,0) is located just below luminary n°2.

About the assessment method, we applied a procedure we used before in many experiments [3][4]. Eight observers were required to evaluate target visibility for each position. The age histogram stretches from 21 to 59 years, with an average age of 43 years. The observers, in groups of three, were placed 83 m away from the first line of the grid, their backs turned toward the target. Knowing that eye position was 1.60 m height, the observation angle corresponds to the standard angle of 1.1∞. On hearing a simulated 'bip' the observers turned round to face the target. On hearing a second 'bip', they reassumed their first position. The duration between two 'bips' was established to produce observations times ranging from 200 to 500 ms.

There were five appraisal ratings:

0, target not visible;

1, target weakly visible;

2, visible;

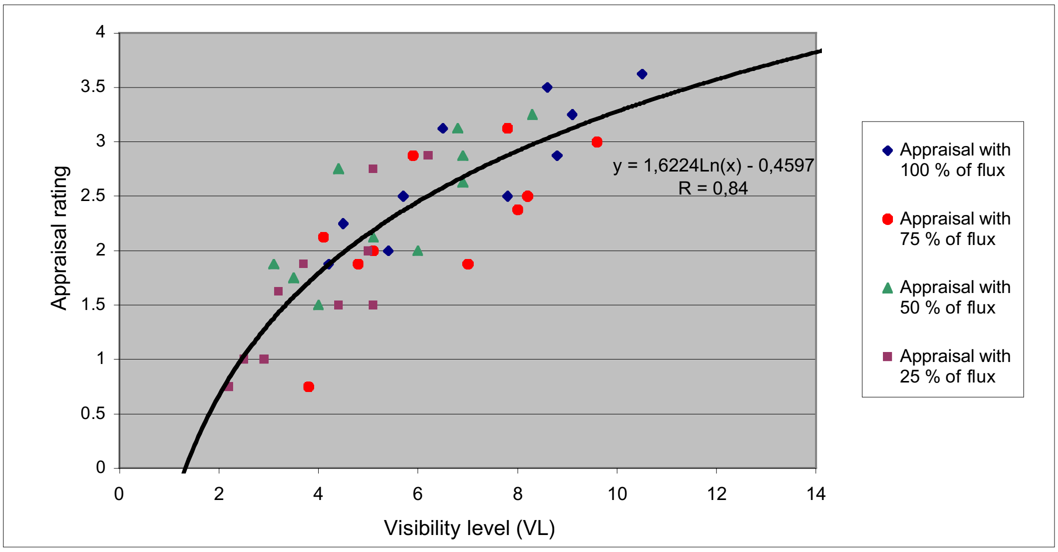
3, satisfactory visibility;

4, good visibility.

For each position, the average ratings were related to the corresponding visibility level in order to give the relationship between average rating and VL of hemispherical targets [5].

The same tests were made for (100, 75, 50 and 25) % of the luminous flux of the lamps and for 10 positions of the grid where the hemispherical target was placed (figure 2). Those luminous flux levels and positions of the ball (dark cells in figure 2) were chosen in order to permit us to have a full arbitrary visibility scale values. At 100%, the average luminance and illuminance of the road are quite correct (2.89 cd/m2 and 30.6 lux) giving a good visibility of targets. Visibility evolutions at 75, 50 and 25% were appreciated in a more efficient way in comparison with the 100% flux.

Figure 3: Appraisal rating of visibility of hemispherical target versus visibility level for 30 m distance between luminaries and different levels of luminous flux.



RESULTS OF APPRAISAL OF 'HEMISPHERICAL TARGET'

As shown in Figure 3, there is a good correlation between the average scores from observer's opinion and the visibility level for hemispherical targets, calculated with Lecocq's model [5]. Standard deviation is ± 0.33.

Concerning the minimum visibility level necessary for a good visibility and comfort (which corresponds to a average rating of 2 in the range of observer's response), we can infer from figure 3 that a visibility level round 4 is sufficient to have a good recognition of objects (visibility) in suburban roads with small traffic and good weather. This value of 4 was obtained, in the present study, with a luminous flux reduction about 50%.

In previous experimentations [3][4], we found a minimum visibility level of 7 for good visibility and comfort, which is a bit stronger but corresponds to installations with less uniformity. In this experimentation of energy savings, due to the great uniformity (figure 1), people seem to appraise visibility of hemispherical targets in a more satisfactory way, even at small visibility levels. Another ground of this difference is the maximum of visibility level of hemispherical targets that observers has to appraise, which is 11 in this experiment and 25 in experiments described in [3][4]. The ladder of appraisal rating is then totally different between this experiment and the 2 others, which leads to an appraisal more satisfactory at small visibility levels in this experiment.

We think that those differences need special experimentations in order to get real explanation.

Figure 4 shows the scattering of appraisal rating for the different levels of luminous flux. Remember that an appraisal rating of 2 corresponds to the minimum visibility of an hemispherical target. One can say that histograms seem to be good for 100, 75 and 50% of flux: most of the observers do not seem to have any problems to detect the target. At 25% of the flux, 43% of appraisal rating are under 2. In other words, it means that characteristics of such an installation are not safe and comfortable for drivers. Flux reduction of 50% seems to be the limit of dimming with a good lighting installation (standard to recommendations of Lighting French Association): Ug = 0.4, Ul = 0.7, L = 2 cd/m2.

In comparison with the experimentation of Sao Paulo [6], one can observe that in Sao Paulo, due to the luminaries, we have the 'ladder effect' of road surface luminance on visibility that led to lots of appraisal rating of 0 and 1 (target non and weakly visible) when luminous flux was at 50% and 25%. The installation has a bad longitudinal uniformity of 0.34.

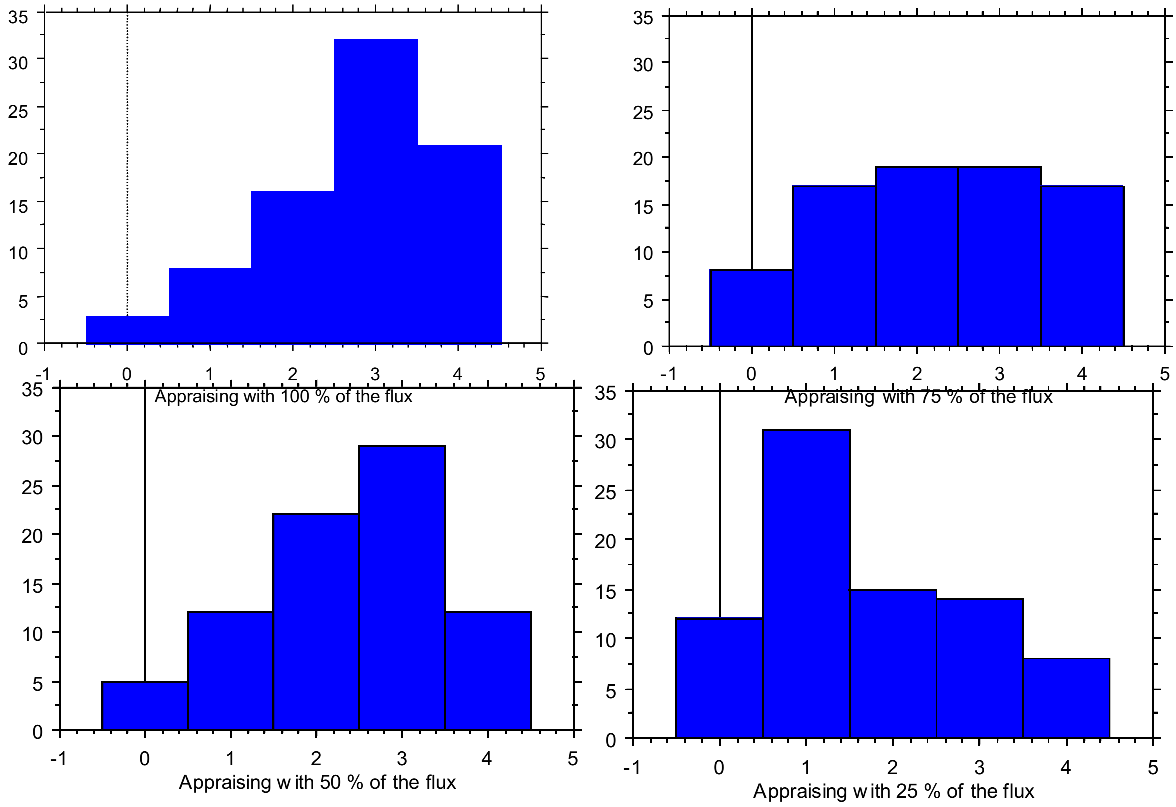
In Rouen (figure 1), even at 50% of the flux, the visibility, due to good uniformity of the installation, is not strongly altered and people feel safe. All appraisal rating at 50% are round 2 or above.

These two experimentations proved that we need for dimming first a strong uniformity and then a good luminance level. In Sao Paulo, we have an average luminance level of 3.74 cd/m2, which is quite good but a poor uniformity, which involves problems of safety and comfort at low levels of luminance.

CONCLUSION

The first goal of this study is an evaluation of the influence of energy savings on visibility. Appraisal of visibility of a hemispherical target linked to a luminous flux reduction system gave a value around 4 for visibility level. One can say that this value is lower than these found in [3][4] but it is linked to the ladder of visibility level and to the good uniformity of our installation.

Figure 4: Comparison of visibility level appraisal rating of hemispherical target for different levels of luminous flux.



About the characteristics of an installation which is going to be dimmed, it is necessary to have first a good longitudinal and transversal uniformity of luminance (in accordance with French lighting recommendations, Ul = 0.7, Ut = 0.4). The level of average luminance must be between 2 and 3 cd/m2. With these conditions, a reduction of the luminous flux until 50% will be able to be operated with out risks for the safety of drivers.

In this paper, we demonstrated that dimmers could maintain good visibility and get energy savings if it is used with a suitable lighting installation. One can say that using dimmers involves other benefits for installation like increase of lamp life due to voltage control, maintained level according to recommendations with depreciation of the installation and possibility of increasing luminance levels with traffic conditions.

We now intend to install another flux reduction system, this time, on each column, in order to compare it.

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