Unified Glare Rating as a measure of visual comfort

Dragan Vuckovic, Nenad Cvetkovic, Dejan Jovanovic and Miodrag Stojanovic

Abstract – Visual comfort is one of the essential parameters which is necessary to be considered during the designing process of indoor lighting. The International Committee for Illumination (CIE) adopted the Unified Glare Rating (UGR) formula in 1995, while the procedure for calculating and tabulating the UGR value of indoor lighting luminaires is adopted in 2010. Since then, most manufacturers have started to include data for UGR in their catalogues. Modern software packages for lighting design allow calculation of UGR and therefore provide the possibility to include UGR information in power engineering designs. From the other side, the measuring procedure of UGR, for realised installations, is very demanding, and consequently, it does not apply very often in practice. Because of that, the UGR information for existing installation is usually unknown. The UGR value depends of the light intensity and luminance distributions of luminaires, the luminaire orientation, as well as the level of eye adaptation and the luminaires arrangement (i.e. the angles between viewing direction and direction from the viewer and luminaires optical centres). Analyse and measurements of UGR in the case of the realised indoor lightning installation, show that it is possible to achieve satisfactory visual comfort evaluated by the UGR index using luminaires with worse UGR. It is also possible that using the luminaires with the satisfactory UGR does not always result with required visual comfort conditions. Based on that, one can conclude that it is not enough to choose a luminaire having a satisfied UGR. Still, it is necessary to consider other parameters that affect visual comfort and make the simulation of complete room scenario. That results with the need for establishing close cooperation of all professions during the design process.

Keywords - Unified Glare Rating (UGR), visual comfort, indoor lighting.

I. Introduction

There are many studies realized in the mid-twentieth century, in order to propose expression that includes glare influence from the luminaires located in the observer field of view. In 1963 the Illuminating Engineering Society defined the formula for the Visual Comfort Probability (VCP) [1]. Numerous experiments were realized in real workplaces, with observers who gave their subjective and personal opinion about visual comfort. The reflectance coefficients of the ceiling, walls and floor during experiment setup were 0.7, 0.5, 0.2 and 0.3 respectively. Various scenes and lighting scenarios were realized. Based on the obtained results, two diagrams corresponding to the two luminaire types are defined. In that experiment, two groups of luminaires have been used. Group A includes luminaires without luminous lateral side, while group B includes luminaires with luminous lateral sides higher than 30 mm. Eight luminance limiting curves have been defined for visual comfort estimation. Designers have used luminance limiting curves method for a long time, but the development of information technologies provided the possibility for proposing an expression that can quantify the level of visual comfort. The International Commission on Illumination (CIE) defined the formula for calculating UGR in 1995 [2]. According to the realised researches, obtained results and experience, the expression is proposed as following:

$$\mathrm{UGR} = 8\log\left[\frac{0.25}{L_b}\sum\frac{L^2\omega}{p^2}\right] \qquad (1)$$

where is:

L_b - the background luminance

L - the luminance of the luminous part of each luminaire in the observer field of view

ω - the solid angle of the luminous part of each luminaire in the field of view of the observer

p - position index of the luminaire.

II. UGR as catalogue data

Procedure for calculating and tabulating the UGR value of indoor lighting luminaires is adopted by CIE in 2010 [3]. UGR data for luminaires are given for different room dimension ratios and different reflection coefficients of interior surfaces. The standard EN 12464 [4] defines the range of UGR values between 10 and 30. The typical UGR values are defined: 13, 16, 19, 22, 25 and 28. Also, the Standard defines minimal UGR values for certain visual tasks. E.g. for offices and classrooms, the maximal UGR value should be 19. Luminaires are usually declared for certain UGR value that corresponds to standard room dimensions. Standard room dimensions for UGR luminaires labelling are X=4H and Y=8H (H is room high). Besides that, reflection coefficients of ceilings, walls and the floors are 0.7, 0.5 and 0.2. Fig. 1 shows the correlation between the luminance limiting curves and UGR values. One can see that value UGR=19 corresponds to the luminance limiting curve for illuminance level of 500lx - Quality class 1.

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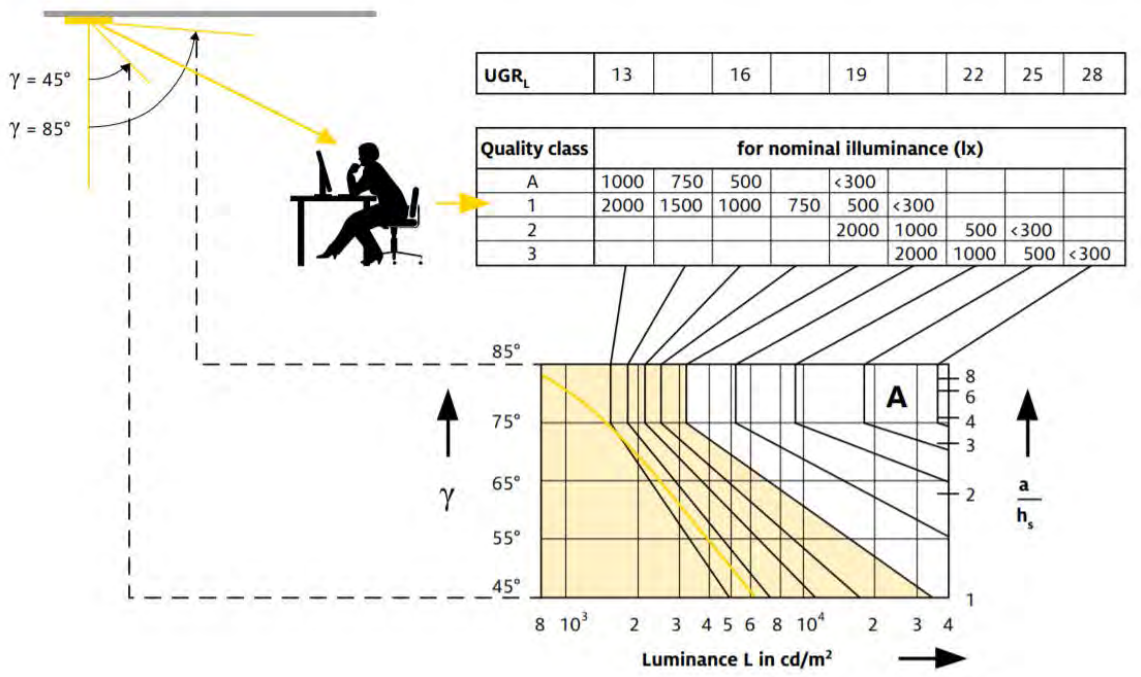

Fig. 1. Correlation between the luminance limiting curves and UGR values

III. UGR –APPLICATION IN PRACTICE

There are cases where calculations with luminaires having a declared value of UGR = 19, give UGR values slightly higher than 19. These results are obtained because of the large curtain-less glass surfaces. The glass influences on a slightly lower value of average brightness of the environment, so that the brightness of the luminaires significantly affects the psychological glare. Opposite to these cases, it happens that the reflection coefficients of the room surfaces, as well as the dimensions of the room, result with the highest value of UGR below 19, although installed luminaires for a standard room, has declared UGR = 22. So, it is obvious that during the designing process of the indoor lighting installations, it is necessary to define the reflection characteristics of the material as accurate as possible and then make a decision of luminaire type.

The LEDs luminaires usually have opal diffusers which have Lambertian radiation characteristics, so they consequently increase psychological glare. There are cases where the situation in terms of visual comfort is significantly deteriorated with the installation of opal diffuser LEDs luminaires. Fortunately, technology is in progress, and there are price-competitive materials for diffusers that provide better light distribution with UGR less than 19. Some manufacturers produce luminaires in which LED modules are retracted related to the surface of the luminaire. In this way, such luminaires are, for the standard room types, declared with UGR less than 16 (even less than 13). Unfortunately, such luminaires are still quite expensive compared to LED "panels" and because of that their massive application did not start.

Measuring of UGR on realized installations is a rather demanding procedure and requires appropriate equipment as well as time to perform all necessary measurements to obtain the results. UGR measurement is usually realized for the most critical observer position. It is interesting that even, the dark school board will affect the deterioration of the UGR value. Concerning necessity to satisfy the vertical illumination value of 500 lx for the board surface, the lamp for the illumination of school boards help to reduce the influence of its dark surface. Using whiteboards, the problem of the impact of the classroom board on visual comfort is reduced, but it is important to avoid physiological glare since their surfaces reflect light.

IV. NUMERICAL SIMULATION AND MEASURING RESULT

In this chapter, numerical results for UGR are given for classroom illuminated by luminaires for general lighting and luminaire for school board. Typical classroom luminaires and furniture setup is given in Fig. 2 and Fig. 3 respectively. The points for UGR calculations are given in Fig. 4, while the calculated results of the UGR are shown in Fig. 5. Dialux evo software package [5] has been used for the numerical analysis. LED luminaires that are used for classroom lighting have declared UGR of 22, for a

standard room. Considering complete setup maximal obtained value of UGR is 19, and it corresponds to the calculating point placed on the back corner.

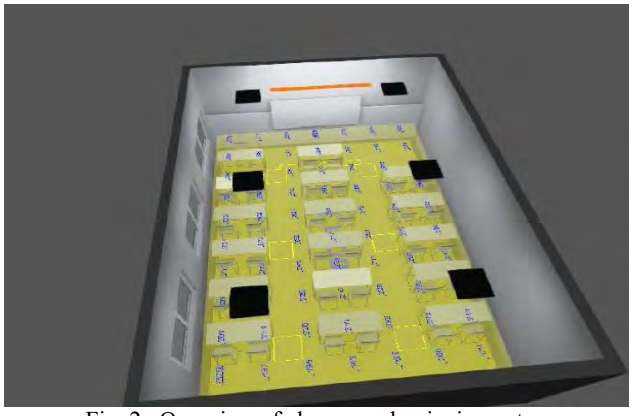

Fig. 2. Overview of classroom luminaires setup

Fig. 3. Overview of classroom furniture setup

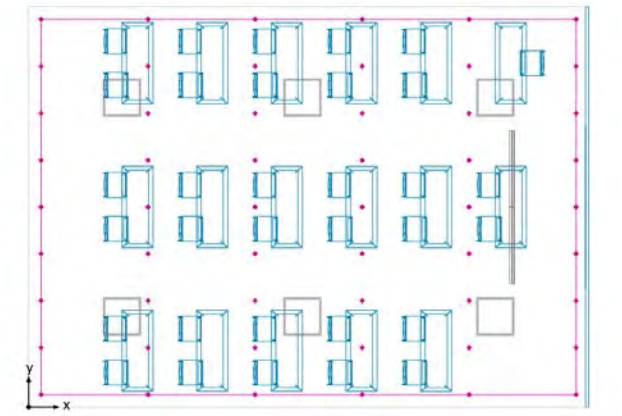

Fig. 4. UGR Calculation points

An overview of surfaces that have impact on UGR value, and measurement equipment are given if Fig. 6 and Fig. 7 respectively. According to the measured results of realized lighting installations, it can be calculated that UGR is in good agreement with one obtained by numerical simulation.

As previously mentioned, software for lighting calculations represent useful tools and helps a lot in the process of estimation of visual comfort.

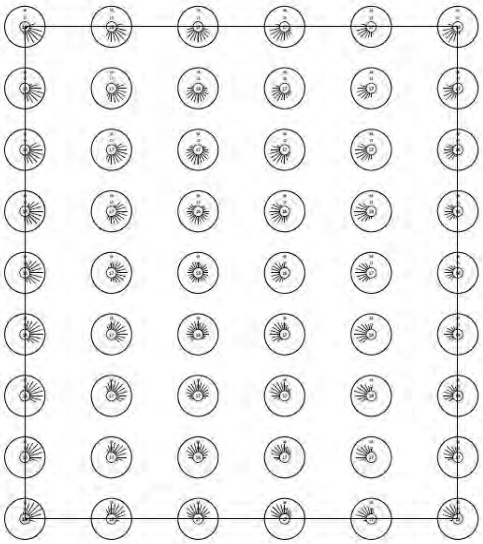

Fig. 5. UGR calculated values

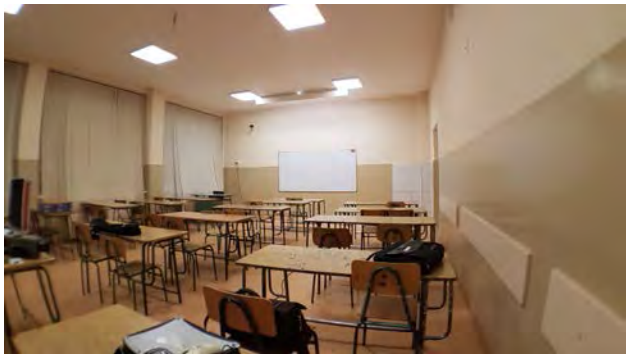

Fig. 6. View from the back corner - UGR measured point

Fig. 7. Measurement equipment for UGR evaluation

IV. Conclusion

This paper presents UGR as a measure of visual comfort. It is an essential datum that should be considered during the designing process of indoor lighting. There are a lot of studies dealing with discomfort glare due to the fact

than the introduction of LED light sources with opal diffusor have significantly decreased visual comfort in the interior lighting. According to the obtained results, it can be concluded that it is not enough to choose a luminaire labelled with satisfied UGR, but it is necessary to make a proper simulation for complete room scenario. So, it is evident that during the designing process of the indoor lighting installations, it is necessary to define the reflection characteristics of the material as accurate as possible and then make a decision of luminaire type.

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