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Luminance ratio at the visual tasks in classroom

Abstract. *Possibilities of action learning methods such as interactive whiteboards, blackboards and whiteboards along with copying to a workbook depends not only on visual comfort, but also on the subjective feeling of the observer. This measurement could be performed objective was chosen as the place of visual task workbook, as the surrounding visual task desk (table) and a background visual task was elected boards according to the type of measurement rooms. Measurements was done by luxmeter and luminance analyzer. Because the evaluating the overall illuminance of the room, so the task area. Further analysis was performed luminance from which it was calculated contrast to which the eye responds and transmits the visual perception.*

Keywords: ČSN EN 12464-1, luminance analysis, illuminance, luminance ratio.

Introduction

The article deals with photometric parameters in classrooms. Classrooms are unique because students regularly alternate between two places of visual tasks. The first (horizontal) area of visual tasks is a work desk with a textbook or workbook. The second (vertical) area is mostly found on the wall behind the teacher's desk and students watch the information on the whiteboard, projector, etc. illuminating, of horizontal spaces of visual tasks is in the European normative described in great detail, but the lighting of boards is described inadequately. The basic reason for this assumption is that there is no distinction, whether the classroom uses white or dark board. This article presents examples of classrooms with different lighting systems, and analysis of the light-technical parameters with an emphasis on the evaluation of the sites under consideration between visual tasks was performed. Three visual tasks were evaluated: illuminance, luminance, uniformity and reflectivity of the material. The values determined are compared within norm CSN EN 12464-1.

Tab 1 Summary of requirements according to CSN EN 12464-1 and CSN EN 73 0580-1

	Maintained illuminance E_m (lx)	Uniformity U_0 (-)	Recommended reflectivity ρ(-)
Notebook visual task	300	0,6	0,75 - 0,8
Desk araound	200**	$U_0 \geq 0,1^*$	0,3 - 0,5
Blackboard visual task	500	0,7	0,75 - 0,8 (white) 0,05 - 0,2 (darkgreen) 0,01 - 0,03 (black) ***
The wall around	$E_m > 75$	$U_0 \geq 0,1^*$	0,5 - 0,8

* task background
** Values in Table 1 - Relationship between illuminance of immediate surroundings and illuminance at the point of the visual task norm CSN EN 12464-1
*** Reflectance of light on common surfaces in accordance with norm CSN EN 73 0580-1

Description of measurement

For measurements were selected four classrooms with different lighting systems. Two classrooms were equipped with fitted with mounted linear fluorescent fixtures. Neither the classroom had additional lighting source. In the first there were three rows of lights, while the second had only two of them. The third classroom was equipped with two rows of mounted fluorescent luminaires with opal covers with additional lighting system with grid luminaires, which mainly provides the lighting of the classroom and not the board. In the fourth classroom is an example of what can go wrong with good intentions-quality luminaires for lighting tables and boards, but their wrong placement. Measurements were performed without daylight to evaluate only artificial illumination. Illuminance and luminance were measured with combination of visual bench seats - notebook and chalkboard - wall. Monitors in the fourth computer room has been measured only by their luminance and not by illuminance, not because they act as light sources. Illuminance in the areas of visual tasks were measured as normal values for the examined sites of visual tasks. The luminance was measured using a luminance analyzer from a position above the eye of the student sitting 1.2 meters. The reflectivity of surfaces were calculated from the obtained values of illuminance and luminance with the fact that we started from the assumption that all surfaces are diffused.

For the calculation of reflectance was determined an equation:

$$(1) \quad L \cdot \pi = E \cdot \rho \Rightarrow \rho = \frac{L \cdot \pi}{E}$$

L – measured luminance (cd.m^{-2})
E – normal illuminance (lx)
ρ – reflectivity (-)

Classroom 1

In this classroom was the blackboard with a ceramic surface for which there was not any additional lighting system for creating vertical illuminance. The lighting system was relatively new (about two years), it was made of nine surface-mounted fixtures with an aluminum grid. All lamps were functional. In one luminaire were light sources of type 4x36W / 840.
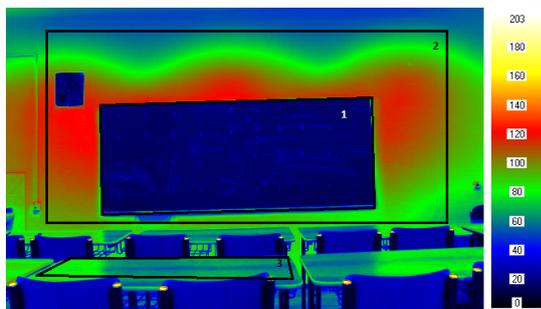
Fig.1. Classroom 1 - luminance map - representation of regions to determine the luminance

Tab 2 Measured values for classroom 1

	Luminance L(cd/m^2)	Normal illuminance E (lx)	Reflectivity ρ (-)	Uniformity U$_0$ (-)
Desk	102,7	777,9	0,41	0,68
Blackboard	15,5	453,7	0,11	0,89
Paper/ Notebook	209,4	819,0	0,80	0,92
Wall	98,5	413,6	0,75	0,8

From luminance map in Fig. 1 shows that even when not using additional fixtures above board, the board was illuminated with fitted lights (red representation on the luminance map - Fig. 1), but the board did not reach the value of illuminance of 500 lux, which is required by the norm CSN EN 12464-1. Conversely illuminance of desks was higher than required by the standard. Standard requirement for illuminance benches and workbook (task area) is 300 lx, and measured illuminance is 777.9 lx. Within the sites of visual tasks we can compare two sites, paper/notebook and chalkboard. The luminance level on the blackboard was 15.5 cd.m-2 and on paper/notebook was 199,4cd.m-2. Comparing the luminance of the workbook and the board, the value of luminance of the workbook was roughly 13 times greater than the luminance of the board.

Uniformity in all evaluated sites meet the standard.

Classroom 2

As in the previous classroom, in this classroom was blackboard with ceramic surface and dark green paint. The lighting system was old (about 10 years), it consisted of 6 surface-mounted lights with aluminum grid, without additional lighting fixtures for board lighting. Lamps were distributed in two rows of three lights. In each luminaire were four light sources of type 36W/840. In this classroom were in the whole lighting system four non-functioning sources.

Fig.2. Classroom 2 - luminance map - representation of regions to determine the luminance
Tab 3 Measured values for classroom 2

	Luminance L(cd/m^2)	Normal illuminance E (lx)	Reflectivity ρ (-)	Uniformity U$_0$ (-)
Desk	116,9	782,0	0,47	0,81
Blackboard	15,5	318,2	0,15	0,63
Paper/ Notebook	199,4	822,5	0,76	0,92
Wall	98,5	374,3	0,83	0,86

The luminance map in Fig. 2 illustrates that during the installation of surface-mounted luminaire only in two rows, there is an insufficient illuminance of middle part of the board. Measured values of illuminance in the central part of the board ranged around an average value of 250 lx, while at the edges of the board was on the right side illuminance of 305 lx (two sources were not working closest to the board) and the left side of 350 lux, but a request for the lighting uniformity was fulfilled. These values do not match the required amount of illumination 500lx, given in norm CSN EN 12464 - 1. Conversely bench illuminance is higher than the standard requires. Standard requirement for illuminance of benches and places of visual tasks is 300lx, measured illuminance was 782 lx. Within the sites of visual tasks we can compare two sites, paper/notebook and chalkboard. The luminance level on the blackboard was 15.5 cd.m-2 and on paper/workbook was 199.4cd.m-2, when comparing the luminance value of workbook is roughly 13 times larger than the luminance of the board. When compared to classroom 1, the measured values are comparable

Classroom 3

This classroom was called gradational - individual rows of benches were of different heights. In this classroom was a wooden blackboard, which was lighted by three symmetrical lights. Lighting system above the benches is composed of eight surface-mounted fixtures with opal cover. In one luminaire should be four light sources of type T8. The age system can not be determined, some lamps were no longer functional. Above the board were three additional lights with aluminum grid. The luminaires are equipped with sources 3x18W/840.
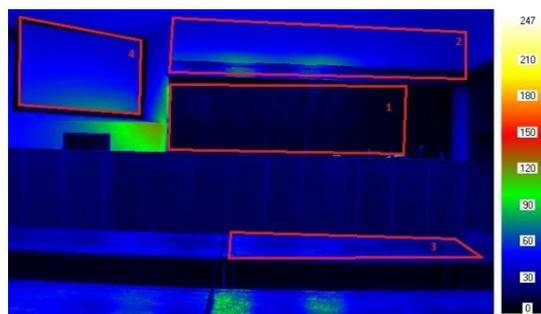

Fig.3. Classroom 3 - luminance map - representation of regions to determine the luminance

Tab 4 Measured values for classroom 3

	Luminance L(cd/m^2)	Normal illuminance E (lx)	Reflectivity ρ (-)	Uniformity U$_0$ (-)
Desk	57,6	761,0	0,24	0,66
Blackboard	12,2	580,5	0,07	0,73
Paper/ notebook	177,7	838,5	0,67	0,92
Projector spot	50,3	219,4	0,72	0,79
Wall	57,4	253,9	0,71	0,81

Tab 5 Measured values for classroom 4

	Luminance L(cd/m^2)	Normal illuminance E (lx)	Reflectivity ρ (-)	Uniformity U$_0$ (-)
Desk	158,5	725,1	0,70	0,92
Blackboard	119,9	561,9	0,67	0,59
Paper/ notebook	203,3	833,5	0,94	0,91
Wall/ projector spot	150,3	558,7	0,84	0,79
Monitor	10,5	-	-	-

In classroom 3 were evaluated three sites of visual tasks, workbook, board, and projection space. The lighting system in the classroom 3 was given two types of surface-mounted lights, symmetrical lights with aluminum grid placed above the board, which is illuminating mostly the teacher's desk, and old lights with opal cover with a light source of type T8. Normal illuminance of board is 580.5 lx. Benches and workbook have sufficient illuminance. Illuminance of projection space on the wall was measured only in artificial light, when illuminated by a projector, the value of the illuminance levels would increase and therefore it would increase the luminance. Using a projector leads to shutdown of the total lighting system of classroom or additional fixtures and might also cause a lack of illumination of desks - workbook. Comparing the luminance value of a workbook (177.7 cd.m-2) and boards (12.2 cd.m-2) as a working place, it was found that luminance of the board is 15 times smaller than the luminance of the workbook.

Classroom 4

This classroom was the newest, it is a computer classroom with a fixed (white) board. The lighting system was new (used for about 2 years, consisted of 9 pieces of fitted lights with aluminum grid and two sources of type OSRAM 54W/840 HO Luminux, COOL WHITE. The board was lighted by two asymmetric luminaires without grid. In the light is one source of type OSRAM 36W/840 HO Luminux, COOL WHITE. Lighting system, consisting of lights above the benches were dimmer-controled. When measuring the performance of the system was 100%.

Fig.4. Classroom 4 - luminance map - representation of regions to determine the luminance

In Fig. 4 is a luminance map, which shows the direction of asymmetric luminaires. The map shows that the illumination spot of fixed board was illuminated rather wall above the board. In this computer classroom was four places of visual tasks, workbook, board, projection space (part of the wall) and a monitor. The illuminance of the board and the workbook is according to CSN EN 12464-1. The luminance value of the monitor with blue screen is 10.5-cd.m-2. When working with a text editor and other common applications, the screen is mostly white, therefore the luminance of the screen will be greater. For projection on the wall the illuminance increases due to the projector and therefore the luminance also increases, depending, of course, on the projected screen and the dominant color. The last two spots are notebook and chalkboard, where the workbook was the luminance of 203.3 cd.m-2 and the board had 119.9 cd.m-2. The workbook is about 1.7 times brighter than the board. Unlike previous classrooms there is a fixed board, which is white and therefore is closer to the luminance of workbook than the green board like in previous classrooms (1, 2, 3).

Conclusion

In the classrooms 1 and 3 are green chalkboards, but with a different surface. The difference in surface properties in this case shows the reflectance factor, which is with ceramic coating (ρ = 0.11 to 0.15), twice that of boards using wood material (ρ = 0.07) with a similar coating, reflectivity of the material is within the limits of conventional light reflection surfaces according to standard CSN EN 73 0580-1. For the board with fixed board the reflectance is 0.67, that is six times greater than boards with ceramic surface, it is also due to the glossy material and white board surface. When comparing the luminance of work spaces workbook - boards, it was found that luminance of conventional boards are 15 times smaller than the luminance of a workbook, but the luminance of the fixed board is only approximately 2 times smaller than of the workbook. For lighting systems in the classrooms 1 and 3 was not sufficient illuminance of the board, as required norm CSN EN 12464-1. In classroom 4 is illuminance of the board sufficient, although the asymmetrical lights illuminate mostly the wall. Uniformity in all classrooms meet the requirements of the standard. It is necessary to adjust the luminance and luminance ratios in all areas of visual tasks (workbook, board) the way that they meet standards for luminance ratios in accordance with CSN 12464-1 Z1 and also requirements of illumination, uniformity of visual tasks. Assuming the compliance of standard requirements in places of visual tasks - white workbook - whiteboard, it can be stated that the luminance ratios are in relation and hence there will be no excessive eyestrain or glare in the rapid changing of visual tasks (workbook - board). If the same classroom will be equipped with a blackboard with a reflectance of about 0.1, it will

reach a substantial increase in luminance - the luminance of the board will significantly decrease.

ACKNOWLEDGMENT

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