MEASURING NATURAL AND ARTIFICAL LIGHTNESS IN THE WORKING SPACE

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ABSTRACT
This paper describes the general characteristics of natural and artificial lightness, as well as the characteristics of artificial sources of lightness, with the supplementary presentation of legal regulative in the Republic of Serbia in this area. The paper also presents three light meters, together with general measure procedure and the obtained and analysed results of measuring lightness in the working environment. Finally, proper conclusions are derived on the basis of the information collected.
Key words: *light and lightness, light sources, legal regulative, lightness measuring.*

INTRODUCTION

The development of light sources has been joined together with the technical development of the human race. Oil lamps, torches and candles were in use until the 19th century and the appearance of the petroleum lamps. These lamps were then in use until the turn of the 20th century and the advances in the development of materials, and hence the invention of the electric light bulb and the production of first electric lamps. Since then, the light has been available in unlimited amounts. The demand for greater security and better quality led to the rapid development of the light design.
Lightness has in contemporary world become a very dynamic sector that utilizes the most modern technologies with new optical systems in order to provide the most efficient lightness, leading to the appropriate application of electrical energy and materials suitable for recycling and presenting significant conditions for environment protection.
In average, a person spends 90% of their life in an enclosed space. In order for the human organism to function properly, this space needs certain conditions to be provided. In many cases, whether it is domestic or working environment, the artificial lightness at least partially replaces the natural – sun light, though in some cases it is replaced completely. Light is the most important element of an interior design, primarily due to psychological effects set on the persons spending time in a space.
The use of appropriate lightness in the working environment can improve the productivity and concentration.

NATURAL LIGHT AND LIGHTNESS CHARACTERISTICS

Light can also be defined as a characteristic property of all senses related to the visual system and originating from the activity of the system.
For the lightness to be adequate in a point of the built space, i.e. surface, it is necessary to have three interacting influences: a) direct influence of the flux of the visible sky segment; b) the influence of the inter-reflected light from the secondary light surfaces: walls, ceilings and windows; and c) the influence of the reflected component opposite to the built obstacle or the existing element in the terrain configuration.
The intensity of the interior lightness does not have permanent value and its variations depend on several influences: geographic position, seasons, part of the day, building orientation, cloudiness, aero pollution, etc.
Spatial distribution of the natural light will depend on the following: light surface area, light surface disposition, combination of methods of light entering, as well as the height and shape of the main built volume.

In both natural and artificial lightness there is the possibility of the glare. Glare is a discomfort in vision or reduced vision ability or both simultaneously. It is caused by the great luminance or contrast in the vision.
According to the origin, glare can be divided into:

1. Direct (caused by the light source, and depends on the brightness of immediate and intermediate light source surroundings) – the glare source and the observed objects are in the same direction,
2. Indirect (caused by the light sources on bright surfaces in a room: working surfaces, appliances and other surfaces) – the glare source and the observed objects are not in the same direction,
3. Reflected – caused by light reflection from the light objects on surfaces, and especially with the presence of reflected images of light objects near the observed object.

Glare in natural light is caused by:

- Size of the light surface,
- Disposition of the light surface in relation to the observed point in the working plane,
- Disposition of the light sources in relation to space,
- Manner of space interior manufacture,
- Direct impact of sun rays, etc.

Glare consequences are as follows:

- Physiological glare,
- Psychological glare,
- Blinding glare (dazzle).

Glare can be reduced by the following: glass coats of lime or gypsum milk, diffuse glass usage, curtain usage with possible regulations, exterior roof projections, and the like, with their dimensions and positions depending on the side of the world orientation, i.e. sun ray angle. [4]

ARTIFICIAL LIGHTNESS CHARACTERISTICS

Electrical lightness is divided into general and local. General lightness has to ensure sufficiently distributed level of lightness on a working surface, which is observed in relation to the entire room. For this purpose, uniformly distributed light bulbs are utilized.
General lightness is characterised by the functional distribution of light bulbs regarding visual tasks or working areas in a room. With this system, the lightness of the entire working space is necessary and it is achieved by the symmetrical light bulb distribution. It ensures the flexibility of the working place locations in a room and the uniform lightness of the entire space.
Local lightness is utilized for lightening relatively small area comprised of the visual task and its immediate surroundings. It can be achieved by light bulbs situated near the visual task or with the distant reflectors. One has to take care of the glare as well. Local lightness is most commonly used together with the general lightness system, whose level should be at least 20% of the general lightness level. [4]

ARTIFICIAL LIGHT SOURCES

Since light sources like petroleum lamps, torches and candles are not in use any more, it can be said that all artificial (technical) light sources are actually electrical light sources, since they work on the principle of turning electrical energy into light.
Electrical light sources can be divided into two groups:

1. Incandescent (in the current flow through the metal thread, heating and radiation emission in the visible spectrum segment appear):

- Light bulbs with incandescent filament
- Light bulbs with incandescent filament and halogen element (iodine, bromine);

2. Luminescent (in the current flow through gasses or metal vapour there is an electrical magnetic radiation which in one segment enters the visible spectrum segment):
   - Low pressure (0.1 to 1.3 Pa): fluorescent pipes and sodium bulbs of low pressure;
   - High pressure (3 to 9 Pa): mercury bulbs of high pressure, metal – halogen bulbs of high pressure, sodium bulbs of high pressure.

WORKING SPACE LIGHTNESS

Working space refers to the entity of material factors and social relations where people perform their working and other activities. Material factors include physical and technical conditions of the working environment, while the social factors include inter-human relationships. The most important physical conditions in a working environment are climate conditions and conditions influencing human perception. Climate conditions are: air, temperature and humidity, while the conditions influencing human perception are: lightness, colours, noise and vibrations. The properties of these factors significantly influences the working productivity flow,working ability,fatigue factor,safety at work,etc. Lightness is a very important factor in a working space and a necessary condition for the working process and all professional activities in larger or smaller degree demand for the vision participation. Since this is a common fact, often there are situations of neglecting important organisation measures concerning proper lightness in a working environment and working space. Inappropriate light influences not only the vision, but also the psychological behaviour and hence the productivity, safety at work, and the like. It is not sufficient only to see, it is significant to see well. This is the basic demand required by the organiser in ensuring lightness as one of significant physical factors in a working space. The best way would be to have the possibility for the work to be performed with the natural light. However, this not being possible everywhere and always, artificial lightness has to be utilized as well.

Due to natural lightness alterations, necessary lightness in a room has to be determined by the number of flux, as well as the natural lightness factors presented in percentage. [5]

Based on certain demands, the average lightness in a room needs to answer the demands of the standards JUS U.C9.100. Table 1 presents minimal average lightness in accordance with the demands.

Table 1. Minimal average lightness in accordance with the demands: a) lightness with incandescent light bulb; b) lightness with fluorescent pipes or similar light sources with multiple colour temperature [5]

DEMANDS	ONLY GENERAL LIGHTNESS		GENERAL LIGHTNESS WITH SUPPLEMENTARY WORKING SPACE LIGHTNESS			
			GENERAL LIGHTNESS		SUPPLEMENTARY WORKING SPACE LIGHTNESS	
	Minimal average lightness (lx)					
	a	**b**	**a**	**b**	**a**	**b**
Very small	30	50	-	-	-	-
Small	50	80	-	-	-	-
Moderate	80	150	30	50	150	300
Large	150	300	50	80	300	600
Very large	300	600	80	150	600	1000
Extremely large	-	-	150	300	over 1000	

LEGAL REGULATIVE

This problem is included in the following legal regulative [1], [4]:

- Law on Safety and Health at Work,
- Statute on prevention measures for safe and healthy work at the working space,
- Statute on the procedure for monitoring and examining working equipment and examining working environment conditions,
- Statute on manner and procedure for risk assessment at the working space and working environment,
- Strategy for safety and health at work in the Republic of Serbia for the period between 2009 and 2012.

LIGHTNESS MEASURING

Lightness measuring in a working space presents a legal obligation and as such presents a measure of the prior safety at work that determines whether the lightness conditions in a working space, i.e. work place, are in accordance with the regulated and set values. With lightness examination, it is also necessary, in accordance with the space purposes and working process type, to determine certain lightness properties such as contrasts, shadows, spatial and time equality, glare and colour light.

Measuring natural and artificial lightness in a working space

Measuring natural and artificial lightness is performed utilizing the light meter YK-2005lx (Fig. 1.) in the facilities of the Institute for Mechanical Engineering in the Tempus classroom.

Fig. 1. Device for measuring lightness YK-2005lx

Lightness measuring in the facility was performed in November 2009 in two measuring places. The first measuring place was selected close to the window, while the other measuring place is the working space on the opposite side of the classroom. Measuring lasted for eight hours, from 8.00 am till 4.00 pm. The day was sunny and pretty bright.

The classroom had stripe curtains, so the measuring was performed in accordance with the three positions provided by these curtains. There were also combinations of natural and artificial lightness, providing in total six combinations – situations.

One situation measuring was performed for five minutes in two measuring places. Time interval between the same working conditions was 30 minutes. In total, one obtained 16 tables in 8 hours.

Besides lightness, there was also natural light measuring in the classroom in the interval of one hour. Measuring results are presented in tables, and result alterations during measuring are presented in diagrams (Fig. 2, 3 and 4).

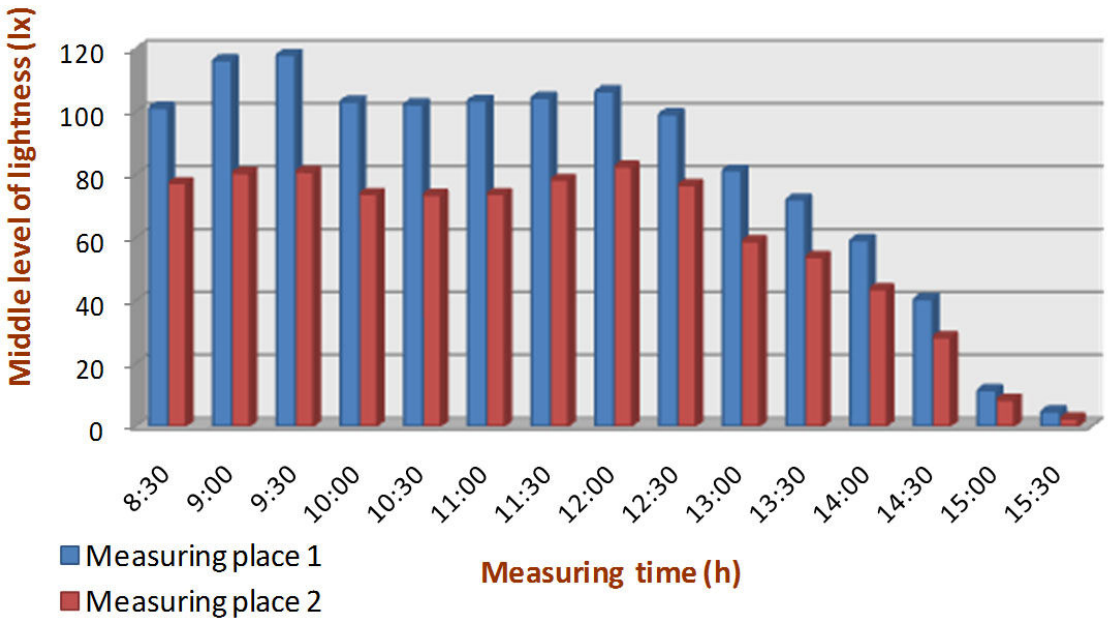

Fig. 2. Survey of the measuring results for the closed curtain position without artificial lightness

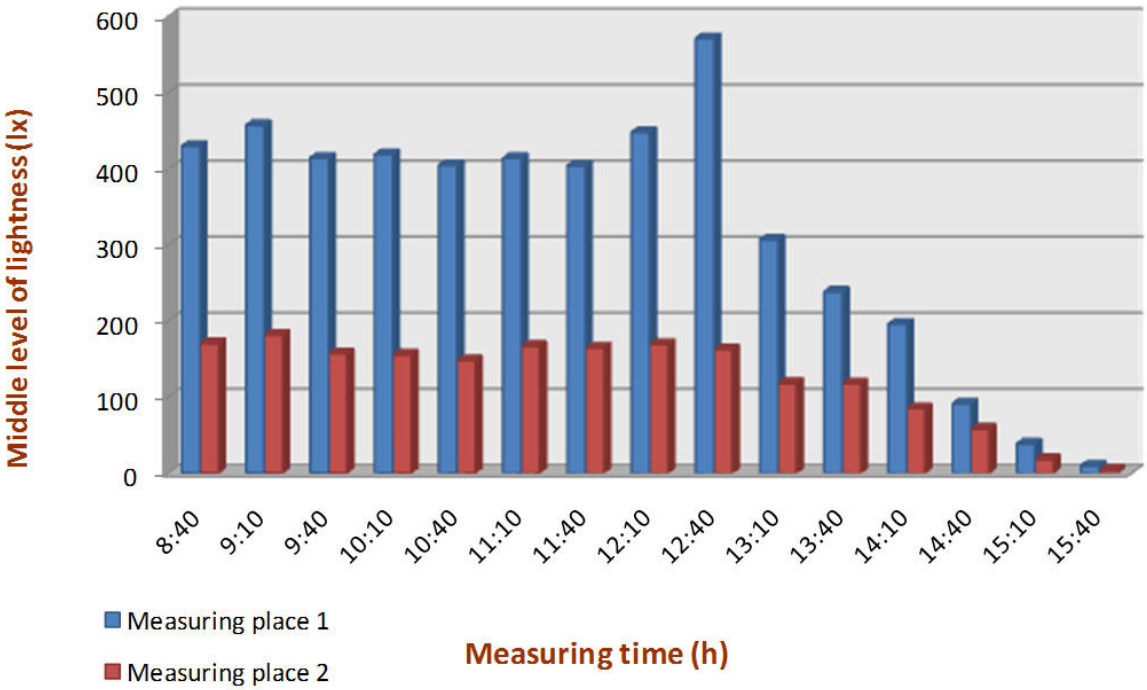

Fig. 3: Survey of the measuring results for open curtains without artificial lightness

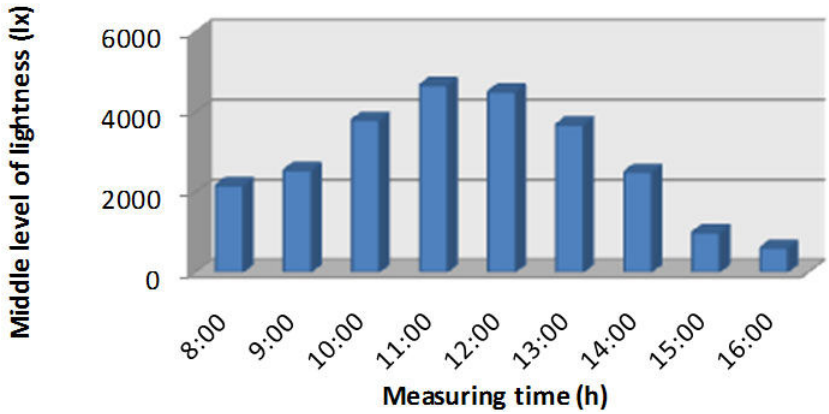

Fig. 4. Survey of the measuring results for natural lightness

CONCLUSION

The lack of space for building commercial and residential areas in large cities is more and more evident. Therefore, there are more multi-storey buildings with commercial facilities without natural lightness. Good lightness of this space is crucial since the employees spend most of the working hours in the enclosed space lightened by artificial light.

It has been proven that the adequate selection of colours and light intensity can have a significant influence on the human organism and people's performance at work, and the estimation is that the new systems of flexible lightness will have greater application in the future.

In the experimental segment of the paper, lightness measuring was performed in diverse conditions in the real working environment. Measuring results demonstrate how the lightness level alters during the day, and how necessary it is to have appropriate artificial lightness that will enable visual comfort and facilitate working conditions.

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