USAGE OF THE LIGHTING INTENSITY STUDY IN SPACE LAYOUT OF THE WORKPLACE

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Abstract
Lightening is a very important factor of work environment. Optimal lightening intensity contributes to eyesight protection. It also enables employees to perform good work performance, what increases working productivity. The document deals with the usage of the lightening intensity study in space layout of workplaces. It points out the possibility of connection the spatial study with light intensity study. This solution brings the productivity increasing to work system human – maschine – environment. Sight perception of the observed events and objects is influenced by three basic components: condition of the sight analyser, condition of the observed object, and lighting. Optimal lighting of the worksite must consider the type and the sight demand factor of the work carried out, and is an important precondition in order to achieve the sight comfort for workers.

Key words: lightening, optimal intensity, space layout study of the workplace.

Classification JEL: M 140 Corporate Culture, Social Responsibility

1. Introduction

People watch and control their activity mainly with their sight. That is why the course of working procedure is co-determined by the vision conditions, i.e. by the lighting and its qualities. Suitable lighting at the worksite can prevent from the sight tiredness and the damage, and thus ensure comfort for a person at work and the resulting increase in the work performance, as well as labour productivity.

2. Factors of the working environment

Working environment is created by a worker and the factors present at the worksite, or related to the executed work, and can influence a person's health (Šebo, Szombathyová, 2003). While working, a person is exposed to the effect of many harmful impacts. Ergonomy's role consists also in, among other things, elimination of these impacts and creation of the optimal working environment. Effect of the working environment factors can be:

1. Negative – one or more factors affect a person in a disturbing, or even harmful way. It is a deviation in intensity of the factors effect from the optimal value, for example noise, vibrations, lighting, radiation, chemical harmful substances, and others.
2. Positive – factors effect is required from the work point of view; they represent the optimal action, they are the precondition necessary to create the working comfort, for example optimal lighting, acceptable climatic conditions, and others.

Some factors of the working environment mutually affect each other. This impact can be demonstrated as:

- mutual active interaction,
- antagonistic impact,
- the factors complement each other (Encyklopedický súbor, 2006).

Important risk factor of the working environment is represented by the physical factors – noise, lighting, microclimate, vibrations, etc. Their negative impact on humans depends on their intensity, duration, and frequency of action. Majority of these factors significantly influence human senses, burden the nervous system and can have a negative impact on a worker's overall health condition (Galajdová, Hitka, 2007).

Objective of this article is not to concentrate on the impact of all (or several) physical factors of the working environment, their measuring and evaluation, but to point out one of them – the lighting and its connection with the spatial arrangement of the worksite.

3. Relation between the lighting and the worksite arrangement

Basic role of ergonomy in designing, construction, or rationalization of the man – machine – environment systems in the field of lighting is to create the optimal optical environment for a person. The optimal optical environment which creates the so-called vision comfort = a pleasant psychological and physiological state in which the sight fulfils its functions and a person feels that his or her sight is good, but also feels good psychically, and the surrounding environment looks pleasant.

Amount and quality of light at the place where the sight work is carried out influence also the sight load, classified on the basis of critical detail's size evaluation, sight and light conditions accommodation. Insufficiencies in the worksite lighting, dazzling during work and overloading the accommodation cause the sight tiredness, which can result in higher frequency of false actions and the risk of work injury (Chundela, 2007).

Optical environment includes also perception of ***light, colour, shape, and space***. Relation between the two segments of the optical environment – the light and the space, is the subject of solution in this section of the article. This relation is illustrated by a simple example of arrangement of the working space used for two purposes:

1. Auditorium with the capacity of 24 seats.
2. Room where the final state examinations take place.

In this space, intensity of lighting was measured; its average value, the daylight factor and lighting evenness were calculated.

3.1. Measuring conditions

Measuring conditions used in this effort were following:

a) Digital Luxmeter device was used for the measuring purposes. This device can be used for fast and easy measuring of light intensity at worksites, staircases, in laboratories, on playgrounds, stadiums, for measuring the emergency lighting.
b) Lighting and its distribution was examined in the interior at the check points allocated within a regular net on a horizontal comparison level. Comparison level height was 0.85 m above the floor. Edge rows of check points were placed 1 m from the internal walls surface. Number of check points was selected so that they provide a sufficient idea of the course of daylight in the interior, or in its functionally selected parts.
c) Type of lighting inside a room – measuring was carried out during the daylight.
d) External measuring conditions – clear sky. Measuring of the external light intensity was carried out at 4 places (through the windows).
e) Room dimensions: 6 m x 6.5 m.

42 measurements were carried out inside the working space. Measured values of light intensity in individual checkpoints are shown in Table 1.

Table 1: Light intensity values in individual checkpoints

Light intensity [lx]					
850	475	360	225	198	190
1000	700	360	275	200	183
900	560	390	300	260	210
300	540	400	350	250	200
1200	800	490	330	320	300
1300	950	570	400	300	270
1000	790	540	400	260	250

Source: own

Measured values of light intensity served as the base for calculation of the average intensity of internal lighting of the space, as well as the average external intensity. Values measured in the interior serve as the base for drawing up the light map of the room shown in Figure 1.

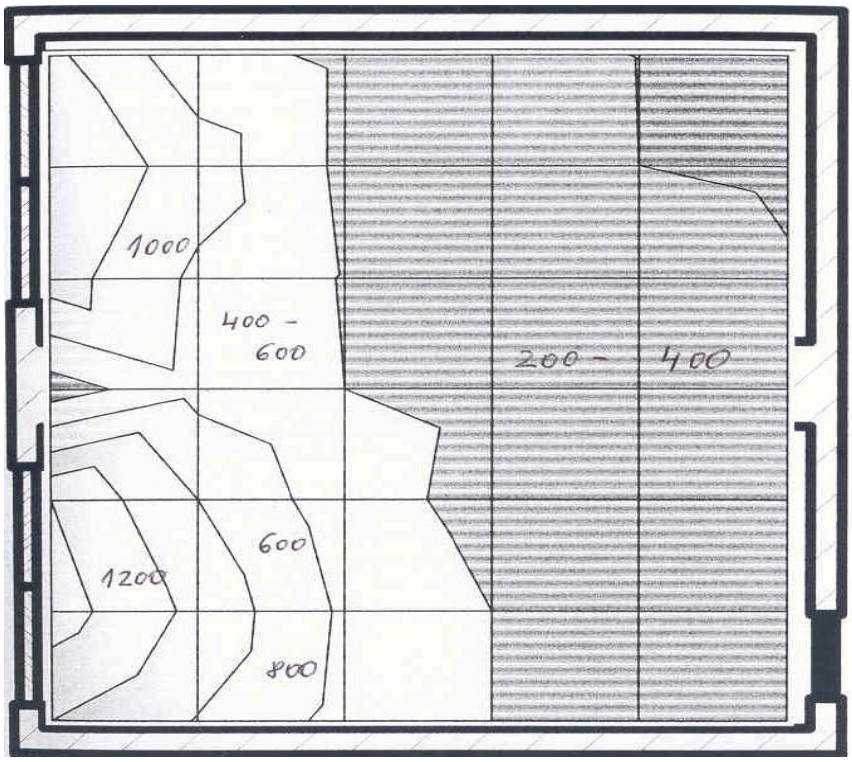

Figure 1: Light map of the working space

Source: own

3.2. Calculation results

Obtained results of realized calculations are following:

a) average intensity of light in the interior: E int. = 479,6 lx
b) average exterior intensity of light E ext. = : 5350 lx
c) daylight factor – given as the ratio of internal and external light intensity (STN EN 12665):

$$D = \frac{E_{INT.}}{E_{EXT.}} \cdot 100 \quad [\%] \qquad (1)$$

$$D = 8{,}96\ \%.$$

d) light evenness – given as the ratio of the minimum and maximum light intensity (STN EN 12665):

$$R = \frac{E_{MIN}}{E_{MAX}} \cdot 100 \quad [\%] \qquad (2)$$

$$r = 14{,}08\ \%.$$

According to STN EN 12464-1 Light and Lighting – Lighting of Worksites, Part 1: Interior Worksites, light intensity inside this type of space must range from 300 to 500 lx, depending on the type of activity. As preparation of students for answers on subjects and discussion of the thesis is not a sight-demanding activity, light intensity of 300 lux can be regarded as acceptable.

The above mentioned standard covers (STN EN 12464-1) also lighting of the close surrounding area of the sight task relating to lighting of work and is supposed to ensure balanced distribution of brightness in the field of vision. Values of the task's close surrounding's lighting are shown in Table 2.

Table 2: Task's close surrounding's lighting

Task's lighting [lx]	**Task's close surrounding's lighting** [lx]
≥ 750	500
500	300
300	200
≤ 200	E task

Source: STN EN 12464-1

Data in Table 2 show that even the close surroundings of the space where the task is carried out is sufficiently lightened. According to (Vyhláška MZ SR č. 541/2007), interior has the lowest allowed value of the daylight factor with the side lighting of 1.5 %; the value we have calculated is thus acceptable. Therefore, we can say the average light intensity, as well as the daylight factor, were in accordance with the recommended values, so in this case it is not necessary to take any additional measures to increase the overall lighting of the room.

On the basis of light distribution in space, the worksite can be arranged so that each worker (student, examiner) has appropriate optical conditions and also enough space to carry out their activity.

In case the insufficient values of light intensity or daylight factor are observed, it would be necessary to create light conditions using the sources of artificial light and repeat the measuring.

If a worksite (classroom) is to serve as the space where state examination takes place, it is necessary to place and arrange there 5 seats for the examination committee members, 3 seats for the preparing students, 1 place for the registrar and also the space for technology.

Layout of the worksites within the space created while respecting the optical environment parameters is shown in Figure 2. Arrangement of worksites is based on isoluxes on the light map, shown in Figure 1.

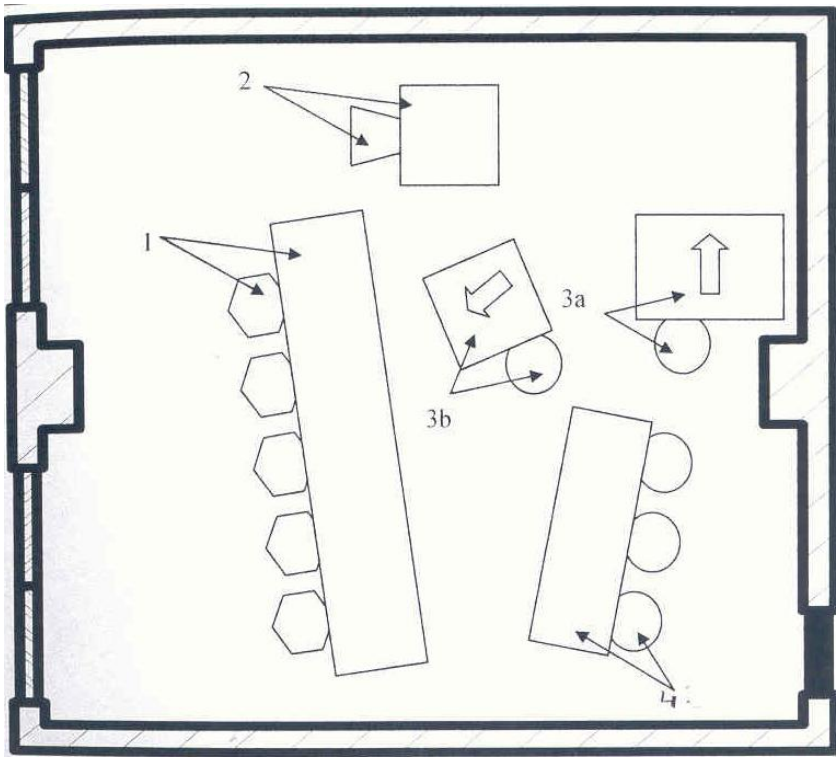

Figure 2: Layout of the worksite respecting the optimal light intensity
Source: own

Legend:
1 – space for the committee members
2 – space for the registrar
3 a, 3 b – space where technology is placed (only one of them is enough)
4 – space for preparation of 3 students.

Light intensity study represents one of the simplest methods to be applied when arranging the worksites in space.

For the worksite spatial arrangement purposes there are many methods to be used, one of them is also the spatial study using the so-called systematic method. It is a systematic examination of relations and finding the reasons for these relations for each pair of monitored worksites. Graphical picture of the relation importance gives the idea of the worksites arrangement in space itself. Decision procedure:

1. Elaboration of the list of all worksites.
2. Determination of mutual relation of each pair of worksites according to the relations table.
3. Assignment of the reasons to the relation of each pair of worksites according to the relations table.
4. Recording the relation and the reason in the register of mutual connections.
5. Graphical picture of relations (colour differentiation).

6. Picture of the worksites layout in space, showing also the material flow and workers mobility.

Importance of mutual relation between the worksites is expressed by using the letters A, E, I, O, U, and X, (Dilworth, 1992):

A – absolutely necessary
E – (especially necessary
I - important
O – ordinary
U – uniportant
X – undesirable.

Reasons of the relation (why the worksites must, can, or must not be positioned in space next to each other) can be different. The reasons may be:

- used device,
- material flow (from one worksite to another),
- staff mobility,
- impact of the working environment factors, e.g. requirements for light intensity, etc.

Relationship among workplaces and its causes are entered to the card. The card is shown in Figure 3. The picture is prepared on the bases of (Dilworth, 1992).

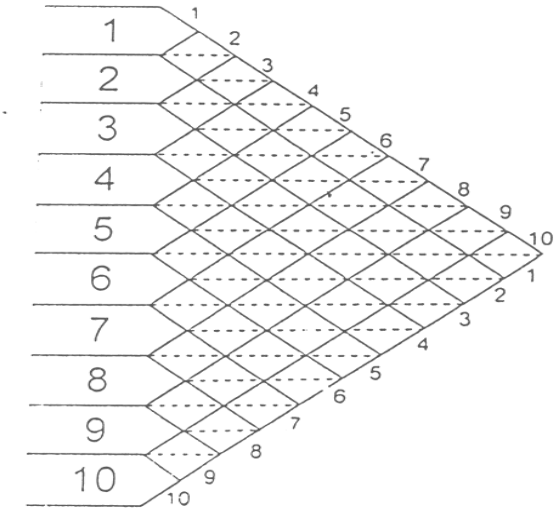

Figure 3: Relationship among workplaces and its causes
Source: Dilworth, 1992

It is a simple method in which it is possible to solve also the colours of worksite, distance between individual worksites, communications, but also the issue of safety at work. If elaboration of the spatial study is carried out in connection with the light intensity study, it is possible to get a more complex solution of the worksite arrangement in terms of reaching the work comfort for workers. The spatial study takes in to consideration also anthropometric data of employees (Hatiar, 2003). This solution brings the productivity increase to work system human – machine – environment as well as decrease of negative mental and physical workload of human at work. This belongs to main aims of Ergonomics.

4. Conclusion

Sight perception of the observed events and objects is influenced by three basic components: condition of the sight analyser, condition of the observed object, and lighting. Optimal lighting of the worksite must consider the type and the sight demand factor of the work carried out, and is an important precondition in order to achieve the sight comfort for workers. Unsuitable lighting influences quality and productivity of work, reduction of work skills, tiredness, injuries, and threats to health at work. It significantly disturbs the sight comfort that represents an important component in the overall work comfort of an individual.

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[9] *Vyhláška Ministerstva zdravotníctva Slovenskej republiky č. 541/2007 Z. z.* zo 16. augusta 2007 o podrobnostiach o požiadavkách na osvetlenie pri práci.

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