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Lighting of the Working Space

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Key words: Light; Working space, Industrial module.

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Abstract

The primary subject of this research is defining the workspace through the impact of light and the size of openings through which light penetrates. In that sense, workplace is taken as a model that is researched and analyzed from the aspect of geometry and proportion. The workplace, being an elementary space in which human's act, represents space which is continuously resided in for the longest period of time throughout the day. For that reason, the natural light penetrating through the light openings, as well as the view from them on the outside world, is a crucial factor for the quality of space.

Lighting the working space

The infinite possibilities that the light has, have been evident since the beginning of architecture and they will be used in continuity in the future. In the architectural space, light changes and appears and so it defines the form [1]. One of the characteristics of natural light is its variability in relation to its intensity, which varies during the day i.e. during the seasons of the year as well as depending on weather conditions and the climate in certain locations. Natural light entering the interior of a space can light it with the necessary quantity of lighting even more than it is necessary, but it is not always the case and not with constant and the same quality of light. As a result of that, light in the working space most often provides lighting, giving pleasant sense and atmosphere necessary for the users of that space. Creating pleasant sense is also basic for creating qualitative architectural space and that is why the researches concerning the use of natural light in architecture nowadays are more and more pronounced and necessary.

Light in the working space no matter whether it is administrative or industrial, should provide healthy, safe and comfortable working environment. When considering these three factors, day light should fulfill the following criteria in order to obtain good, efficient, visual environment with performances of good lighting, uniformity of light (in the working space), light conditions in the field of vision, avoiding flash, light distribution (in the interior of the working space) and the characteristics of the color of the light.

Frequent accidents, errors and the general performances are directly connected with the quality of light. For the people working the maintenance of constant level of productivity requires short periods for relaxation during which moments, other sensual simulations will be free from monotony. In this way, the symptoms of physical and mental fatigue will be avoided. Generally taken into consideration, the light entering only through the light openings into the office space with day light satisfies the need for light. On the other hand working at night or in shifts means working contrary to natural biorhythm. The American scientists have discovered that in a space with the level of lighting over 2000 lux, the secretion of melatonin (hormone for sleeping) may be held back or delayed, whilethe level of lighting over 500 lux (the most usual level of office lighting), does not have an impact on the physical benefits of the people working there. The light working space increases the physical activity, thus lighting becomes one of the factors contributing to better

performances of the employees. On the other hand, the increased quantity of light may have opposite effect i.e. making the working space worse, causing fatigue. Depending on the kind of work and the ambient, the lighting should be planned separately in accordance with the demands and interests, which should be taken intoconsideration with the aim to achieve the best and qualitative results.

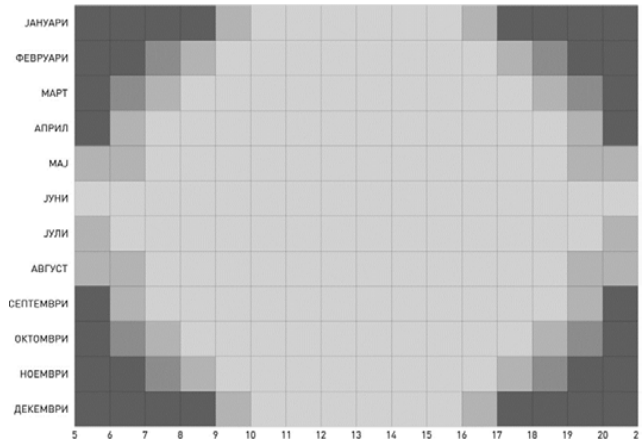

Figure 1: Graphic survey of lighting greater or equal to 5000 lux during the year and in the period of day.

Even during the process of planning appropriate way of solving the problem for qualitative daily light of the working space can be found. Then all factors defining the dimensions and the kind of glass surfaces should be observed and respected with the aim to provide corresponding and qualitative amount of day light during the day. The international references for lighting working spaces recommend to define architectural elements on the basis of minimal daily outside light of 5000 lux[1] for the most critical days during the year [2], (see Figure 1).

Working spaces can be lit by natural light in two ways, through the openings on the façadewalls and through the openings in the roof construction.

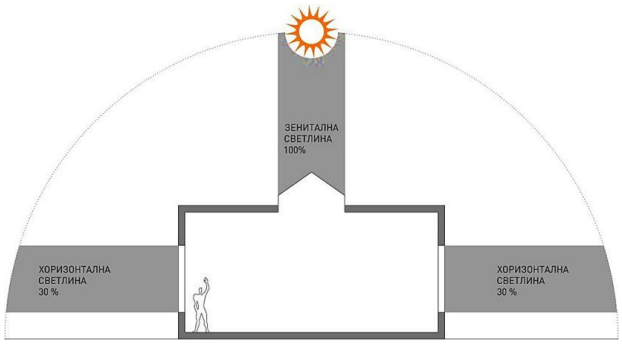

Figure 2: Light distribution of diffuse sky

Lighting entering the working space through the openings in the façade walls has to fulfill the following conditions (see Figure 2 and 3):

- The height of the transom to be as small as possible i.e. the distance between the upper edge of the window and the ceiling to be as small as possible. The less is the height of thetransom, the more natural light enters the space

- The height of the parapet in the administrative objects should be 1 meter, while in the industrial objects around 2 meters or less in the technology itself permits.

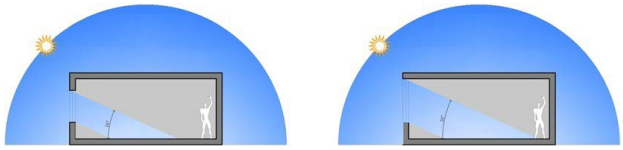

Figure 3: Penetration of light with transom and without it on 21 December, angle of penetration24°

Vertical light openings permit entrance of corresponding quantity of natural light only if the working spaces have small depth. The maximum depth of the working space [B] caused by the need for corresponding lighting with natural light in the entire space and the height of the working space

[H] can be explained in the following way:

- B = 2 x [H-0.8] m; for one-sided vertical lighting with the window glass

- B = 3 x [H-0.8] m; for one-sided vertical lighting with the glass prism

- B = 4 x [H-0.8] m; for bilateral vertical lighting with window glass

The primary parameters used to define the dimensions of the working space are the standardsfor minimal spaces for the employed in administration. These parameters are different depending on the countries in which they are applied (see Figure 4).

COUNTRY	MINIMAL OFFICE AREA PER EMPLOYEE IN M²	COUNTRY	MINIMAL OFFICE AREA PER EMPLOYEE IN M²
GERMANY	30	POLAND	14
DENMARK	20	RUSSIA	14
ITALY	20	MACEDONIA	12
NETHERLANDS	20	BELGIUM	12
SWITZERLAND	20	GREECE	12
SWEDEN	18	IRELAND	12
FRANCE	17	AUSTRIA	12
SLOVAKIA	15	HUNGARY	12
SPAIN	15	BULGARIA	10
ENGLAND	14	ESTONIA	10

Figure 4: Normative for minimal necessary areas for office area per employee

It is necessary to pay special attention to those working places where the light openings are ofbigger dimensions, then where the openings present are unique communication with the exterior surroundings and through which it is possible for the users to observe the exterior dynamics and the changes happening during the day and the night. It is also necessary to

provide easy accommodation of the eyesight to easy perception of close and distant subjects, which is important to establish psychophysical balance of the employed. This is the reason why it is essential the openings on the façade walls to be translucent when looking at the landscape or to be dim when qualitative view cannotbe provided.

When planning industrial objects, various forms of profile of the working space are seen which can be dictated by various needs of technological process, static-constructive conditions, economical,architectural and the other specific needs for lighting i.e., for using natural light. Very often the position of light openings is subordinated to the general architectural conception, but the situation can be vice versa i.e. the openings dictate the form and the general architectural composition of the total industrial complex. The basic condition for daily, natural lighting of some industrial areas is to provide such a space – an object, which will be well lit up all the time during the day, independently or togetherwith permanent additional artificial lighting [3]. Daylight can be defined on the basis of the need of lighting of certain visual activity or it can be planned exclusively from the point of view on pleasant and visual conveniences. Defining and determining the visual activity is closely connected with certain limitations concerning the flexibility when using working spaces. In practice, it is suitable to achieve free conception for various kinds of activities and at the same time to define the general level of necessary lighting to work. If all tasks are of the same character – unified and if there is a need of moderate level of work lighting, the day lighting can be coordinated with the visual task. However, if the working activities are different and with different needs for the lighting of the visual environment, then it would be irrational to plan the whole space according to one of the needs. In such cases, it is necessary to define the zones of the working spaces concerning the needs of the visual environment.

Lighting the working space – industrial module

In most cases the day light is brought into the working space through the openings placed one- sided (lateral) or two-sided (bilateral). How deep the daylight will penetrate into the space when the sky is diffuse depends on the height and the kind of the opening, as well as the kind of glassing and preparing the interior space. On the other hand, it can be said that the depth of the working (industrial) space or the working tract depends on the need for the intensity of day light. In sections that are high 5 meters or more, a tract of the 10-12 meters can be built with one-sided or 20-24 meters with bilateral lighting. These parameters refer to working space where on the most critical place of the space, it doesnot demand lighting greater than 100 lux.

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The obtained results are shown on graphic and table presentation and on diagrams. For each researched model, an average value got in the middle of the working space has been taken into account. For each characteristic height of the space, various dimensions of light openings have been examined. The obtained results are shown in graphics through interactive diagrams, which can be used in defining the quantity of light for certain heights of the space. These results make it possible and help to defineeasily and quickly the quantity of lights in the working space with great depth, considering the fact that the value of the level of lighting changes relatively a little in the examined control points which are close to the middle of light opening. The same results can be used to define the place, the dimension, as well as the height of the openings with the aim to get optimal lighting of the working space in the industrial objects in which certain working activity is carried out.

Diagrams of the obtained results from the examined models of working space – industrial modules

The obtained results from the examined models are presented on ten interactive diagrams. Each diagram is for a certain height of working space. Each of the obtained transformed curves presents a certain value of the lighting of the space. These interactive diagrams can be easily applied in many ways:

- When the height of the light opening is known and when the parapet is constant or changeable then the level – intensity of lighting in any point of the space can be defined.

- With the given i.e. standardized intensity of lighting in the most critical point of the space,an adequate height of the light opening can be chosen.

- When only one of the parameters is known, as well as the height of the light opening or

standardized value of lighting, it is easy to define the depth of the space.

Inspecting the obtained results for working space – industrial modules

A collective nomogram has been made as a common result of the obtained diagrams. This nomogram can be used by any architect without any previous knowledge of the problem of day light.It can also be applicable when defining the dimension of light openings as well as for defining the proportions of the working space when the intensity of lighting is known. In an easy way, the optimal depth of the working space in which any working activity is done can be determined. The collective nomogram is made by copying the intersected values of the curves got by and presented in the diagrams 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10, for various heights of the working space and the required intensity of lighting. This way we get new dependence [new diagram – nomogram] between the height of the light opening shown on the ordinate and the depth of the space presented on the abscess (see Figure 7 and 8).

If all these mutual influences of the dimension of light openings are connected, the lighting they give and the depth of the architectural space, we can conclude that the height of the light openings (its dimension), the lighting and the depth of the space are inseparable and proportional one to another (see Figure 6).

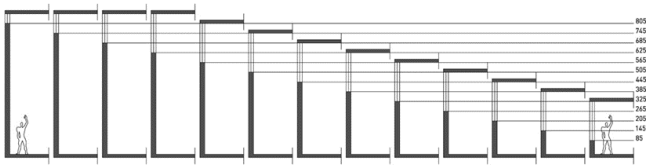

Figure 5: Models / lighting research for working spaces in industrial objects with various heights of the parapet

The obtained values refer to the control points on the working and horizontal area of 0.85cm over the floor level and on the variable height of the parapet depending on the dimension of the opening.

The height of the parapet in the examined models varies from 0.85 to 7.80m (see Figure 5). The analysis has been made for the use of one-sided lateral lighting with worth orientation for uniform sky during the four most characteristic days in the course of one calendar year. The two equinoxes and the summer and winter solstice (21st December, 21st March, 21st June and 21st September at 12 o'clock) have been analyzed. The estimates done and the results obtained refer to the climate zone of Republic of Macedonia i.e., for the latitude of 42° and longitude of 21,26° (Skopje). The basic parameters on which these researches are based are the following specific qualities of the used materials:

Architectural elements (level of reflection): Floor (50.0%), Wall (32.5%), Celling (50.0%), and Factor of pollution of glass surface (0.9%), Transmission of the glass (80%).

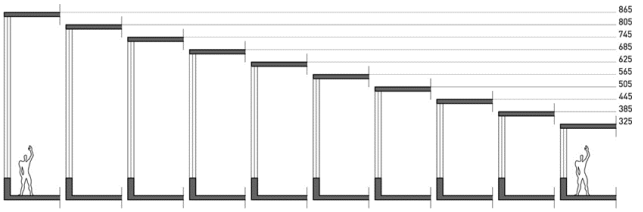

Figure 6: Models / lighting research for working spaces in industrial objects with various heights of the space

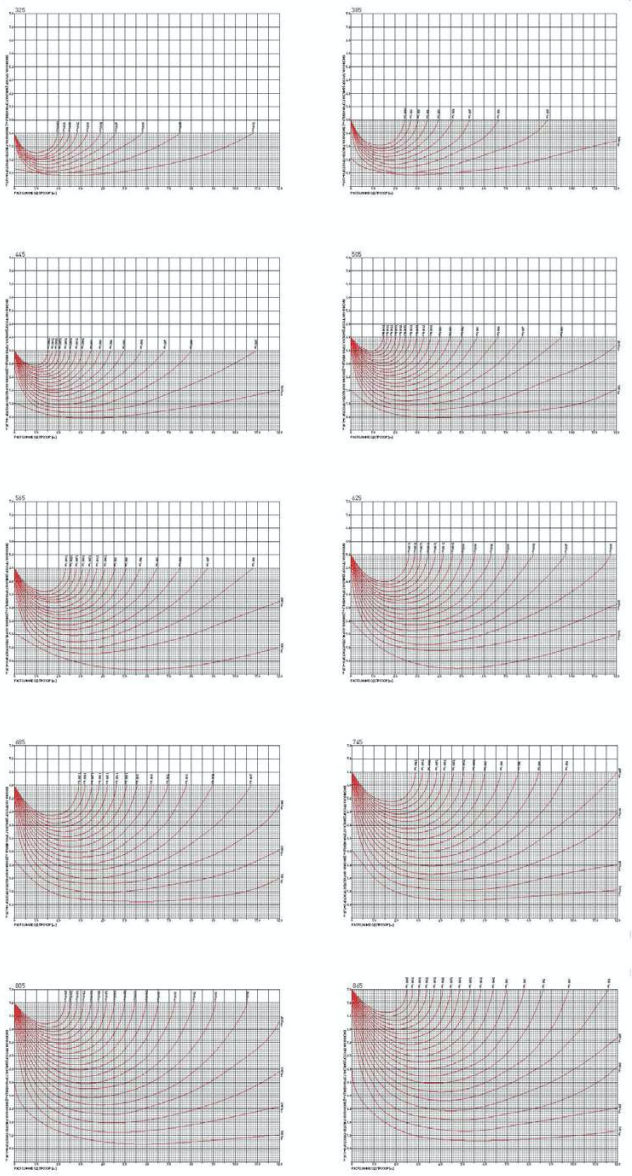

Figure 7: Nomograms [1, 2, 3,4,5,6,7,8,9 and 10] for various heights of the working space and therequired intensity of lighting.

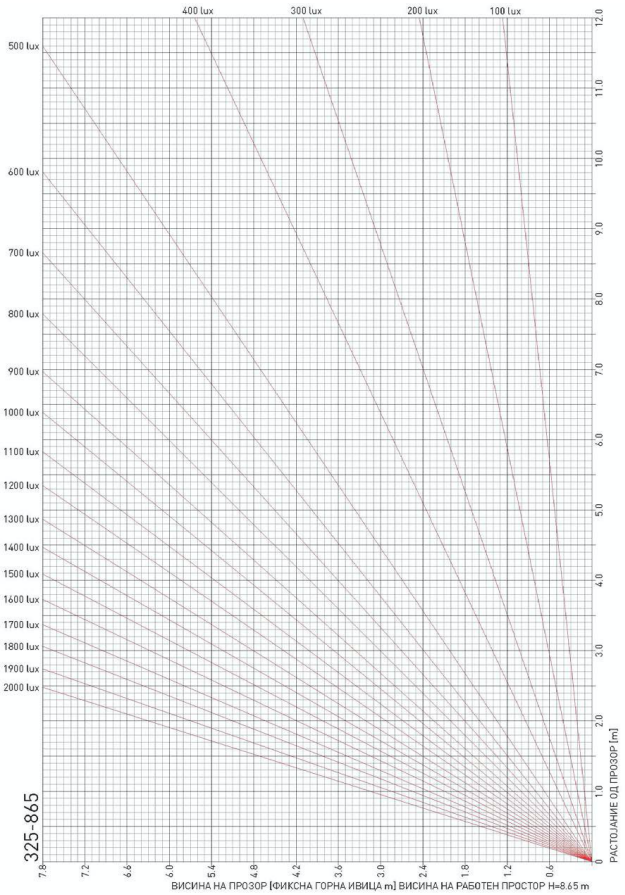

Figure 8: Nomogram

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