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Commercial Lighting Design in Human-Centered Lighting Concept

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Abstract

In this study, the lighting design of a building in the Organized Industrial Zone, which was converted from a warehouse to a commercial kitchen, was designed according to the Human-Centered Lighting concept. Point lighting calculations were made for commercial kitchen environments with artificial lighting. In order to reduce the negative effects of lighting on human health, lighting that will not disrupt the circadian rhythm should be provided. By using direct lighting, without changing the architectural design, it has been tried to provide optimum lighting suitable for human biology with low-cost artificial lighting arrangements. According to WELL standards, an average of at least 500 lux conditions should be provided in the relevant work area on counters and other food preparation or production areas in Commercial Kitchen Lighting. This area, which was designed as a warehouse for this purpose, was designed as a commercial kitchen in terms of lighting. As a result of the design, a lighting design was made in accordance with the WELL standards according to the Human-Centered Lighting concept. In this way, the visual comfort of the working personnel is improved and optimum circadian effects are provided.

1. Introduction

Each place has different lighting needs according to its usage characteristics and intensity. Lighting designs; Direct use of elements such as geographical features, architectural design, general concept, intended use. Lighting design is one of the major costs of the overall architecture and the entire space. Because artificial lighting sources have direct effects on the people using the space. Just as the architecture of the buildings is planned according to their intended use, the lighting design is planned according to their useful life and purpose. It reveals different placements in lighting designs, even in the smallest units of the houses, in presentations used in different shapes and purposes such as kitchen, living room, bedroom. As soon as the sun begins to illuminate the earth, the main determinant of the day cycle is daylight. Daylight determines when to wake up and when to sleep. Daylight has a direct effect on people both physically and psychologically. For this reason, the basic element in building designs from the past to the present is daylight. Facade direction and window width in buildings are shaped accordingly. Daylight is also decisive in terms of its effects on health and energy savings. A controlled building that can make maximum use of daylight provides a healthy and energy-efficient use. However, nowadays, the usage density criterion has become a priority rather than the use of daylight in designs. That's why there are offices, hospitals, and even homes that don't get any light. Developed as a solution to this situation, Human Centric Lighting brings the light intensity and color temperature of daylight to indoor spaces. Thus, it supports the correct balancing of people's biological rhythms even in an area completely independent of the outside world [1-4].

Human Centric Lighting (HCL) enables people to increase their living comfort by supporting them with the right artificial light with features closest to daylight. Acting as a simulation of the sun indoors, HCL primarily aims to provide a healthy light. Light is very important for the circadian rhythm, which determines people's daily hormonal patterns. The

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biological effects of light conditions can be listed as the sleep-wake cycle, heart rate-blood pressure, body temperature, hormone release, metabolic activities, and concentration-motivation.

In traditional lighting designs that do not have the dynamism of natural daylight, the light has a constant color temperature. Whereas, daylight has a blue wavelength in the morning and a yellow wavelength in the afternoon. This difference in daylight affects the intensity of activities and mobility during the day. Artificial lighting that does not adapt to daylight can lead to disruptions and imbalances in the circadian rhythm. Circadian rhythm disorder manifests itself as fatigue, lack of motivation, anxiety, and sleep disorder in humans.

HCL supports the circadian rhythm at the right time, with the ideal color temperature and light intensity. It can be adjusted with wireless automation systems, making it possible to be specially designed for spaces or personal needs. Thus, a suitable cycle can be created for people working at different working hours [5-8].

2. Human – Centric Lighting Concept

Human Centric Lighting, at the right time, with the right artificial light support, artificial light; It is a lighting concept that aims to increase the comfort of life by regulating its visual, biological, and psychological effects. The Human-Centered Lighting concept is aimed at using the effects of light sources in the most efficient way. Natural sunlight, which is our source of life; changes dynamically in color temperature, and quantity. However, due to today's conditions, artificial light sources are used mostly in indoor places where we spend our time. These artificial light sources usually have a fixed color temperature and color intensity. This situation adversely affects human health.

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The use of artificial light, especially in corporate buildings, brings with it intense energy consumption. In such cases, energy efficiency is ensured in the long term thanks to the Human Centric Lighting concept. In addition, it enables the creation of healthy and high-productivity spaces by providing positive effects on people. The HCL concept, which includes holistic lighting and space planning, appropriate installation, and correct application processes, is dynamic and functional from start to finish. As the difference between artificial lights and sunlight increases, it becomes difficult to adapt and the Circadian Rhythm is disturbed. The light spectrum of good lighting should be similar to the spectrum distribution in daylight.

The appropriate Lighting also directly affects the perception, aesthetics, comfort, psychology, and performance of people. While all these elements are negatively affected in a place that is not properly illuminated, it is possible to increase efficiency by creating a direct positive effect on people, thanks to the Human-Centered Lighting concept. The concept of Human-Centered Lighting, which can be applied to all living and working areas, has critical importance especially for offices that are used heavily and for places such as hospitals, which have great importance for health. In accordance with the principle of Human Centric Lighting, it is aimed to provide the highest benefit in terms of efficiency and health by calculating the psychological and biological effects of light on people. With this concept, not only energy is managed efficiently; but At the same time, by increasing the contribution and creativity of the employees, much more benefits than expected can be created. In visual lighting design, the goal is to support visual acuity level by setting a threshold for adequate light levels and by asking for lighting to be balanced indoors. According to the WELL standards, an average of at least 500 lux lighting should be provided on counters and other food preparation or production areas in Commercial Kitchen Lighting.

According to the Circadian Lighting Design criteria specified in the WELL standards, the purpose of Human Centric Lighting is to support circadian health by setting a minimum threshold for daytime light intensity [9-11, 16-19]. Light is one of the main drivers of the circadian system, which begins in the brain, regulating physiological rhythms throughout the tissues-organs of the body, influencing hormone levels and the sleep-wake cycle. The method should be given in detail and clearly in terms of the reproducibility of the study. According to the Human Centric Lighting concept, Equivalent Melanopic Lux is measured in the vertical plane at eye level with respect to the human body. According to the Human Centric Lighting concept, the aim of visual lighting design is to set a threshold for sufficient light level and to support balanced visual acuity. According to WELL standards, an average of at least 500 lux lighting should be provided on counters and other food preparation or production areas in Commercial Kitchen Lighting [9-11].

2.1. Lighting Criteria

The lighting quality should always provide adequate visual performance for the task involved. Average illuminance level, uniform distribution, glare control, and color rendering are the quality parameters taken into account in providing visual comfort. Inadequate lighting makes documents or computer screens difficult to see due to inappropriate lighting levels, glare, and unwanted shadows. Insufficient lighting prevents the correct perception of the environment, objects, and colors. Artificial lighting systems can be useful in environments where daylight is not sufficiently utilized. By controlling the light intensity, optimum illumination can be made according to the hours [20-26].

The human-oriented lighting concept is measured as the vertical lighting level. Horizontal lighting requirements in the working plane are a familiar concept. However, there is no planar conversion method between vertical lighting and horizontal lighting. Since the amount of light in the vertical plane is a combination of direct light from a luminaire, light reflected from walls, light reflected from ceilings, and light from windows, this method, which depends entirely on how the light is transmitted to the space, is called the Equivalent Melanopic Lux value. For Circadian Lighting Design, the criterion of providing any limit value condition of U_o value is not taken into consideration [9-11, 27-30].

2.2. Illuminance Level

The illuminance level, which is the ratio of the incident luminous flux per unit time to the surface area, is defined as equal to the luminous flux of the surface divided by the area of that surface. Its symbol is 'E' and its unit is lx. However, the unit used in America is a foot candle'. Mathematically, E (Illuminance Level) is called the ratio of Luminous Flux to Area. While the intensity of light falling on a given surface area does not change, the illuminance level in that area does not change. The 'Illumination quality' changes. However, although the light intensity remains the same, the illumination level depends on the change in distance. In general, when referring to the measured and recommended illuminance levels, the values reaching the horizontal operating plane are referred to. However, the levels read on different surfaces depend on the location of the source and the measuring instrument. They differ in the same environment. For example, if the illuminance level meter is towards light sources, from horizontal (close to the line of sight)) high values will be read [20-26].

3. Results and Discussion

In Commercial Kitchen Lighting, an average of at least 500 lux conditions have been tried to be achieved in counters and other food preparation or production areas. For this purpose, an area designed as a warehouse is designed as a commercial kitchen in terms of lighting. The warehouse, which has been transformed in terms of lighting, is seen in Figure 1.

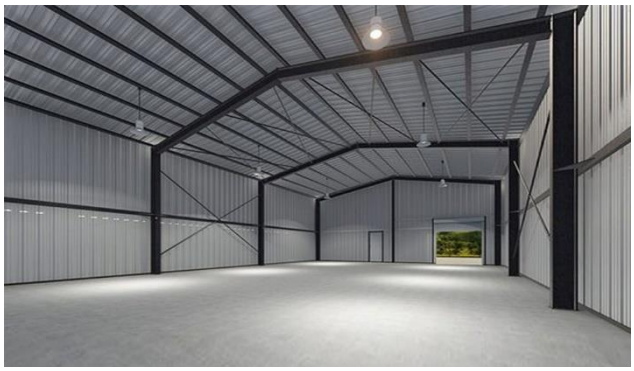

Figure 1. The warehouse transformed in terms of lighting.

The ceiling height of the lamps is 7 m. for this reason, the distance between the surface to be illuminated and the lamp is included in the calculation as 7 m. According to the Human Centered Lighting concept, an average of 500 lux lighting should be provided in the $E_{average}$. The luminaires to be used in area lighting

have been selected considering the level of illumination, the brightness level of the area and walls, lighting homogeneity, and economy. Calculations were determined according to the point illuminance method.

The lighting system for area-surface parameters is in a double-row suspension arrangement. The top view of the area for which the Point Lighting Calculation is made is shown in Figure 2.

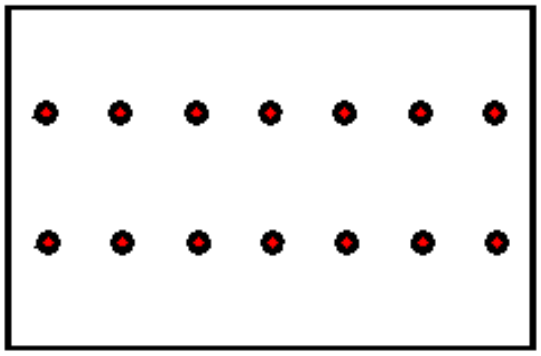

Figure 2. The top view of the area for which the Point Lighting Calculation is made.

As the lighting parameters, features such as the distance between lamps, lamp height, lamp distance to the surface, IP protection class, pollution rate, cleaning time, and maintenance factor were selected as the lighting parameters. For the luminaire parameters, variables such as the angle of the luminaire relative to the surface, the luminaire's power, its lifetime, and luminous flux were taken into account in the calculation. LED luminaires with a luminous flux value of 55000 lumens were used in the commercial kitchen environment. Luminaire angles were chosen as 0, floor reflectivity 0.10, and maintenance factor 0.93 (for less polluted environments cleaned annually). An enclosed area with insufficient natural lighting is chosen. The working area is 12 m wide and 90 m long. The area between the two luminaires where the point lighting calculation is made is divided into 90 points. The average illuminance level ($E_{average}$) was calculated for each rectangular area by dividing the 12 m * 11 m area into 90 equal parts of 1.10 m * 1.333 m dimensions. $E_{average}$ should provide 500 lux and above.

Table 1. Lighting parameters

Height of luminaire from ground (m)	7
Distance between luminaires (m)	11
Armature Angle (degree)	0°
Type of the Lamp	LED
Lighting Arrangement	Double row
Lamp luminous (flux)	55000
Area Length (m)	90
Area Width(m)	12
Ground reflectance factor	0.10
Maintenance Factor (once a year)	0.93
Height of luminaire from ground (m)	7

In Table 1, for the daytime, direct lighting scenario, the condition of having an $E_{average}$ value of 500 lux and above for 90 points in the selected area has been checked. Circadian Lighting Design was successfully completed with direct lighting during the day. Because while the current level of light is insufficient, it is understood that the amount of light that human biology will need is provided in this environment by increasing the amount of light. The illuminance values of 90 points calculated for direct lighting are shown in Table 2.

Table 2. Illuminance values for 90 points calculated for direct lighting.

	E_{min}=100 Lux		E_{max}=631.96 Lux		$E_{avarage}$=500.96 Lux					
m/m	0.550	1.650	2.750	3.850	4.950	6.050	7.150	8.250	9.350	10.450
0.667	328.808	326.709	351.947	366.130	363.079	363.109	366.222	352.103	326.931	329.099
2.000	426.705	428.186	453.276	488.577	510.843	510.872	488.659	453.415	428.387	426.967
3.333	504.162	502.317	520.878	581.300	627.982	628.006	581.372	521.000	502.488	504.390
4.667	573.610	573.158	586.788	627.863	631.934	631.956	627.929	586.901	573.319	573.823
6.000	622.362	586.300	583.452	613.171	586.355	586.378	613.238	583.565	586.462	622.576
7.333	573.610	573.158	586.788	627.863	631.934	631.956	627.929	586.901	573.319	573.823
8.667	504.162	502.314	520.878	581.300	627.982	628.006	581.372	521.000	502.488	504.390
10.000	426.705	428.189	453.276	488.577	510.843	510.871	488.659	453.415	428.387	426.967
11.333	328.808	326.709	351.947	366.130	363.079	363.109	366.222	352.103	326.931	329.099

4. Conclusion and Suggestions

Indoor lighting should be used to support circadian rhythm in a variety of application areas, such as schools, offices, hospitals, prisons, and other businesses operating in confined spaces where area lighting is provided. In the new generation of human-centered architectural design, lighting systems must not only meet the visual needs but also support the biological (eg sleep-wake order) and psychological (eg mood, mental fatigue, stress) needs of the individuals. In human-oriented lighting solutions, lighting systems that offer optimized light settings according to the time of day, weather (cloudy or sunny), and the body's metabolism status (sleepy or stressed) should be used.

As a result, it is necessary to make maximum use of daylight for the physical and biological needs of human beings and for a sustainable environment. In addition to the use of daylight, making artificial light suitable for human nature positively affects health. Commercial Kitchen Lighting has an average of at least 500 lux in counters and other food preparation or production areas. Special lighting should be made by the lighting designer according to the needs and standards of each project. Human-Oriented According to the lighting concept, architectural lighting design was made in accordance with the criteria of WELL standards. In this respect, the lighting design is successful because the $E_{average}$ value was calculated as 500.96 lux in this study.

Statement of Research and Publication Ethics

The study is complied with research and publication ethics

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