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INVESTIGATION OF LUMINAIRE AND ROOM'S PROPERTIES ON UNIFORM LIGHTING IN A HOME EXAMPLE

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IN

OPTICAL ENGINEERING

BY

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Supervisor

Prof. Dr. Ahmet Necmeddin YAZICI

by

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September 2021

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Sümeyra ŞAHAN

ABSTRACT

INVESTIGATION OF LUMINAIRE AND ROOM'S PROPERTIES ON UNIFORM LIGHTING IN A HOME EXAMPLE

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The main goal in the lighting system is to provide a clear image. It is very important to provide a clear image system in offices, various work areas, residences, road lighting, shopping malls, hospitals and security areas. It takes time for the human eye to adapt to different light levels in different environments. Therefore, a homogeneous image, in other words utility, is sought in ambient light. The illuminance level should be planned taking into account all the standard planning methods limited to empty rooms, not just the objects in the environment. In order to address this situation, the DIALux program has been developed, which provides the calculation of the luminance and brightness distributions in the rooms. In this study, a home lighting design, which is widely used with LED luminaires, was made and the illumination calculations were compared by making changes on this design. Therefore, the lighting systems, luminaires, calculation methods and the results arising from the program used will be examined and inspected.

Key Words: Luminance, Armature, Light, Color, DIALux.

ÖZET

ARMATÜR VE ODA ÖZELLİKLERİNİN BİR EV ÖRNEĞİ ÜZERİNDE HOMOJEN AYDINLIĞA ETKİSİNİN İNCELENMESİ
ŞAHAN, Sümeyra
Yüksek Lisans Tezi, Optik Mühendisliği
Danışman: Prof. Dr. Ahmet Necmeddin YAZICI
Eylül 2021
44 sayfa

Aydınlık sistemindeki temel hedef net görüntüyü sağlamaktır. Ofisler, türlü çalışma alanları, konutlar, yol aydınlatması, avmler, hastaneler ve güvenlik alanlarında net görüntü sistemini sağlamak çok önemlidir. İnsan gözünün farklı ortamlarda farklı ışık seviyelerine adapte olması zaman alır. Bundan dolayı ortam aydınlığında homojen görüntü bir başka deyişle düzgünlük aranır. Aydınlık seviyesi sadece ortamdaki nesneler değil, boş odalarla sınırlı tüm standart planlama yöntemleri ve çoğu aydınlatma bilgisayar programı dikkate alınarak planlanmalıdır. Bu durumu ele almak için odalardaki aydınlık ve parlaklık dağılımlarının hesaplanmasını sağlayan DIALux programı geliştirilmiştir. Bu çalışmada LED armatürler ile yaygın bir şekilde kullanılan ev aydınlatma tasarımı yapılmıştır ve bu tasarım üzerinde değiştirmeler yapılarak aydınlık hesaplamaları karşılaştırılmıştır. Dolayısı ile aydınlatma sistemlerini, armatürleri, hesaplama yöntemlerini ve kullanılan programla beraber doğan sonuçları incelenecek ve denetlenecektir.

Anahtar Kelimeler: Aydınlık, Armatür, Işık, Renk, DIALux.

''Dedicated to my family''

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CHAPTER I

INTRODUCTION

It is a priority to have an efficient and comfortable environment in places illuminated by daylight that lasts all day. Thanks to the sufficient illumination level, the users' ability to see the area more easily will be effective in reducing the feeling of absolute fatigue. Visual comfort conditions required for users should be provided with a static, stable and evenly diffused light for use.

The lack of adequate and evenly distributed natural lighting and reaching the desired level of illumination with the support of artificial lighting increases energy consumption. Thus, determining the natural lighting performance is a detailed method that provides a quantitative and qualitative examination of the potential of daylight in the environment and the lighting of the building.

In this study, basic information about space lighting with artificial light sources and the relationship between space design and lighting are examined. We will examine any lighting project, lighting calculation and luminaires and how it is reported in the dialux evo application.

CHAPTER II

LIGHTING and RELATED DEFINITIONS

2.1 Light

Light is the case that meets the vision of living things as a result of a radiation emanating from the light source hitting the object or reflecting it directly. An object that is potentially radiant and visible at the same time is called a light source.

2.2 Visible Light

Electromagnetic waves that can be perceived by the human eye are called visible light. The wavelength of visible light is between 380 nm and 760 nm. In the electromagnetic spectrum, this area lies between infrared and ultraviolet. The wavelength of visible light is shorter than infrared and longer than ultraviolet.

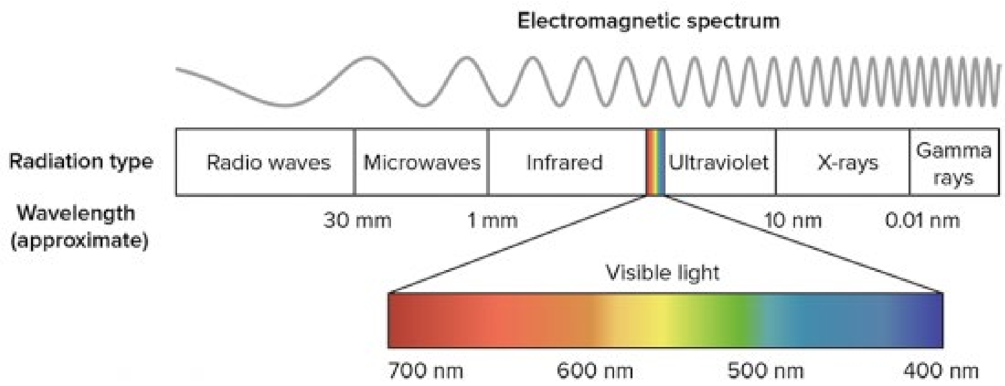


Figure 2.1 Classification of light by wavelength

Light generally refers to electromagnetic waves in the range that includes infrared radiation and ultraviolet radiation, but in some cases, it simply refers to visible light. Light with a wavelength ranging from about 400 nm to 800 nm is called visible light and is the light that humans can see with the naked eye. [1]. Visible light can be defined as the type of light people are familiar with because of their ability to see.

2.3 Wave Theory

In modern physics, it is known that while light has wave properties, it also has particle-like properties.

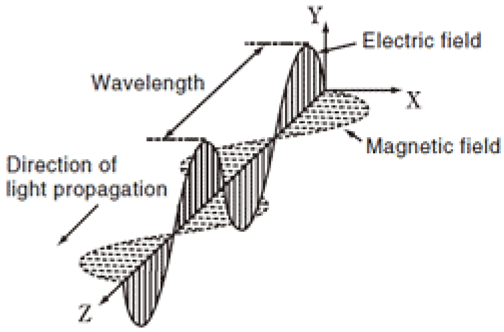


Figure 2.2 Electric field and magnetic field in light

As light travels through a vacuum, it consists of an electric field and a magnetic field that intersect at right angles to each other. [1].The distance between successive peaks of the electric or magnetic field is the wavelength.

2.4 Particle Theory

After the light hits a metal surface, electrons are emitted. The emitted electrons are called photoelectrons. If the wavelength of the light decreases, the number of emitted electrons does not change, but the energy of the electrons increases.

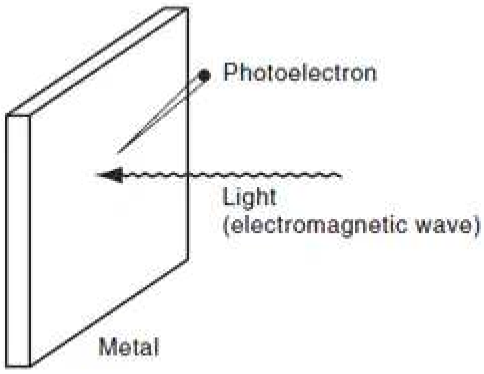


Figure 2.3 Concept of photoelectric effect

At the end of the experiments on the photoelectric effect, it was concluded that light could not be explained by considering it as a wave but could be explained by considering it as a particle. [1].

2.5 Lighting Terms

2.5.1 Luminous Intensity

Unit: Candela (cd)

A light source radiates its luminous flux (Φ) generally in various directions and at varying intensities. The intensity of light emitted in a certain direction is called luminous intensity (I).

Luminous intensity (I) = Luminous flux in terms of space (Ø) / Angle of space (Ω)

2.5.2 Luminous Flux

Unit: Lumen (lm)

As the luminous flux (Φ), the radiant power emitted from the light source and evaluated by spectral eye sensitivity is called.

2.5.3 Illuminance

Unit: Lux (lx)

Illuminance (E) indicates the ratio of incident luminous flux to the surface to be illuminated.

So;

E (lx) = F (lm) / A (m2).

When a light source of intensity “I” is placed in the center of the Sphere with Radius “r”, the flux becomes “4πI” and the k surface area becomes “$4\pi r2$”.

Calculated as luminous intensity (E) = 4πI/$4\pi r2$

2.5.4 Absorption

Taking down of luminous by the object is called. Bright, clear and flat surfaces have less light absorption and high reflection. On matte, dark colored and rough surfaces, light absorption is high and reflection is bad.

2.5.5 Reflection Rate

Each surface reflects the incoming light in different sizes. A dark surface reflects less light than a light surface. This ratio can be found by the ratio of reflected light to incident light. The reflectance rates of the surfaces that are effective in the reflectance rate are given in the table below as specified in the standard TS-12464-1.

Table 2.1 Reflectivity of surfaces

Area	Reflection Rate (%)
Ceiling	70-95
Wall	40-60
Ground	15-35
Furniture	25-45

Table 2.2 Reflection coefficient of color

Colors	Reflection Factor (ρ)
Black	0.05
Dark Red	0.10
Light Grey	0.40
Sky Blue	0.40
Pink, Light green	0.45
Light yellow	0.70
White	0.80

2.5.6 Color Rendering Index (Ra)

Depending on the place used and the purpose of vision, color perception in artificial light should be performed as accurately as possible. (As in daylight) The criterion for this is the color rendering properties of a light source.These lamps help to create a good atmosphere and effect in the space. And these properties are expressed as Ra in the “General Color Rendering Index (CRI)”.

A light source with Ra = 100 displays all colors optimally as under the reference light source. As the Ra value decreases, the correct reflection of the colors will gradually decrease.

CRI 70-75 for the general market, representing 99% of customers in commercial and industrial applications is good enough.

The light sources with the worst color rendering are some fluorescent lamps and, in general, discharge lamps. The lights with very good color rendering are incandescent lamps, halogen lamps, xenon lamps and the lights of some special fluorescent lamps. [3].

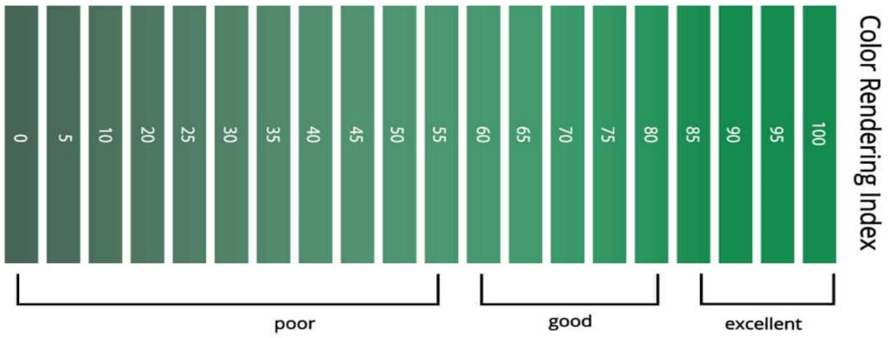


Figure 2.4 Color rendering index

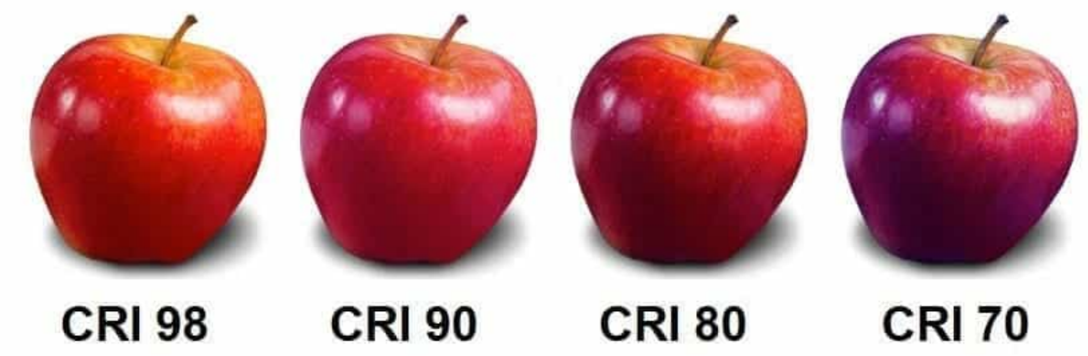


Figure 2.5 CRI values and consequences [5]

2.5.7 Lighting Temperature

In fact, color temperature, expressed in Kelvin, has nothing to do with physical temperature for the user. On the contrary, the color temperature of daylight is defined as cool white in summer times when the bright blue lights of the sun are effective. We also call the orange-yellow or amber light given by the candlelight as warm white. [4]. Color temperature in artificial light sources is usually in the range of 2500 to 8500 degrees kelvin. Light sources according to three light colors classified.

Table 2.3 According to the colors of the light source's temperatures

unit	Color of light	Temperature of light
ww	Warm White Light	< 3300 K
nw	Natural white light	3300 – 5000K
dw	Cool white light	> 5000K

2.5.7.1 Warm White Light (2500-3300 Kelvin)

Color temperatures of 2500 – 3300 kelvin are considered "warm light". Red, orange, yellow and brown are earth tone colors generally used in homes, warm light colors are suitable for these spaces. Warm light is generally softer than bright cold light, providing good vision and a comfortable atmosphere. For this, it is used in bedrooms and living areas.

2.5.7.2 Natural white light (4000-4500 Kelvin)

Although warm light is generally accepted in homes, some people may prefer natural white light. Natural white light has a color temperature of 4000 – 4500 kelvin. Natural white light is preferred in environments decorated with green, white and blue tones. It is preferred in offices and home-offices as it creates an energetic and refreshing mood for people and employees. At the same time, light with a color temperature of 4000 – 4500 Kelvin supports us to see details and makes it easier to see the imperfections in objects. For this reason, places where cleanliness is important are useful in lighting in make-up rooms.

2.5.7.3 Cool white light (5000-6500 Kelvin)

The kelvin degree of the summer sun is technically 5000 – 6500 kelvin light. In other words, the lighting imitates the sun. Due to the excess blue light in 6500 kelvin light, it starts to pose a risk to the eyes. For this reason, it is necessary not to stay in these environments for too long. Cool white light can increase work efficiency in working environments, it is used in offices, garages, jewelry stores, leather and shoe stores, displaying silver objects, sports fields, apart from residences.

Psychologically, it is known that warm white light can feel the ambient temperature 1-2 degrees higher. Accordingly, according to sales statistics, preference for warm white light increases in northern countries, and cold white light preferences increase as they approach the equator. If you have insomnia problems, you should not prefer cold white light in the evenings. Illumination with warm white light should be preferred.

2.5.8 Average Uniformity (U_0)

Uniformity is expressed as the minimum illuminance divided by the average illuminance on illuminated surfaces. It is indicated by the U_0 icon. The uniformity of lighting has significant effects on visual performance both indoors and outdoors. Uniformity U_0 value is found by dividing the minimum illuminance E_{min} value resulting from the calculations according to the current lighting scheme by the average illuminance value E_{avg}.

$$U_0 = E_{min} / E_{avg} \tag{2.1}$$

The uniformity value is determined by the type, number, light angle and mounting position of the luminaire. [10].The human eye needs some time to adapt to different light levels. For this reason, homogeneity is sought in illuminated environments.

Uniformity values greater than 0.60 are recommended in working environments. Because above this level, people do not notice the change in light level and feel more comfortable.

In illuminated environments, as a result of the failure of any light source, the minimum illuminance value and accordingly a decrease in the average smoothness value can be observed. In this case, if the evenness value falls below the minimum required for the environment, maintenance should be performed earlier than the scheduled date.

2.6 Lighting Sources

Lighting can be divided into two as natural and artificial according to the origin of light. At the same time, it can be divided into two as indoor and outdoor lighting according to the place illuminated. Natural lighting is done with the most appropriate way to distribute natural light. In addition, the use of natural light with artificial light and the placement and design of buildings in order to provide economic conditions are also the subject of natural lighting.

Artificial lighting is provided almost exclusively by electric light sources today. According to the sources used, this lighting can be divided into sub-types such as lighting with incandescent lamps, lighting with discharge lamps and lighting with fluorescent lamps.

Interior lighting is the lighting of closed places. In this type of lighting, ceilings and walls send light to the work plane by reflection and help illuminate the work plane. Illumination of houses, schools, hospitals, factories, theaters, cinemas and similar places is included in this class. [6].

2.7 Light Distribution

- In direct lighting, the light is directed directly from the source, not from any reflective surface to the place where it is desired to be illuminated. Direct light fixtures scatter 90 to 100 percent of the emitted light.
- Semi-direct luminaires scatter 60 to 90 percent of the emitted light downwards and the rest upwards. These luminaries employed in technics where strong light isn't needful e.g., storage areas.
- General diffuse luminaries scatter 40 to 60 percent of the emitted downwards and the rest upwards.
- Direct-indirect luminaries in terms of the near horizontal light fixtures that provide little or not at all is a kind of general diffused lighting that give light. These lighting are more preferred than general diffused luminaires that distribute the light equally in all destinations because this feature provides lower gloss directly in the glaze area.
- Indirect luminaries scatter 90 to 100 percent of the emitted upwards.

- Semi indirect luminaries scatter 10 to 40 percent of the emitted downwards and the rest upwards. [7]. This lighting scheme is primarily used for indoor light decoration purposes.

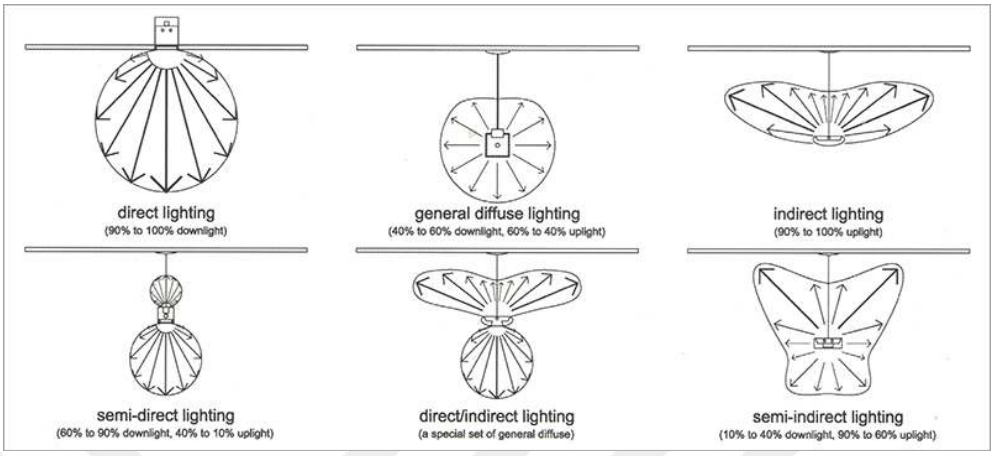


Figure 2.6 Types of light

2.8 Daylight

In an open place, for example, in a country, the illuminance on the horizontal plane varies between approximately 1,000~100,000 lux, depending on the weather, during the daytime. In daylight illumination, illumination is calculated by selecting a "useful minimum" between these values, which shows the utilization limits. In other words, the dimensioning of the glass surfaces is done according to this minimum.

The factors that play a role in choosing the minimum daylight are as follows.

- The sunshine and cloudiness of the country or regions,
- The natural environment of various regions
- Economic factors;
- Various physiological adaptation problems

There are a wide variety of factors such as these, which are of great importance for our country.

When the minimum shrinks, the glass surfaces enlarge, some expenses increase, auxiliary lighting decreases.[8]. The associated expenses are also reduced. As the minimum increases, the glass surfaces decrease and the auxiliary lighting increases.

The useful minimum used most of the time in Germany is 3,000 lux, in France 500 lux. C.I.E. (International Commission on Illumination) recommends 5,000 lux.

2.8.1 Daylight Measurement and Evaluation (For building with side light or top light)

Daylight inside the building can be evaluated according to the following quality criteria:

- Illumination intensity and illuminance
- Equality, homogeneity
- Dazzle
- Shading

For the evaluation of daylight inside the building, the illumination strength of the covered sky is always taken as a basis. Daylight filtering into the building from the side window.[10]. The ratio of daylight is calculated with the D (Daylight-Factor) calculation. This ratio is found by the ratio of the indoor lighting strength (Ei) to the outside lighting strength (Ea) in parallel. Indoor daylight is always given as a percentage.

$$D=Ei/Ea \times 100\% \quad (2.2)$$

The unit of measure for luminous intensity - specifically in artificial light - is Lux (Ix). In indoor areas, daylight is given as %.

2.9 Purpose of Lighting

- Physical Lighting: The aim is to be able to see figure with their shapes, colors and details easily. That is called Physical Lighting.
- Ornamental Lighting: Instead of showing the objects in detail, it is to leave a more aesthetic effect.
- Fascinating Lighting: Target is to show off. It uses high illuminance levels, colored lights, variable light patterns and flashing patterns.

CHAPTER III

LAMPS

A device designed to produce visible radiation is called a lamp. Incandescent lamps, which are the most basic light source today, produce light with incandescent radiation. Discharge lamps, known for their high luminous efficiency, produce light by electrical discharge in the gas. The value of the luminous flux produced by a lamp by consuming 1 Watt is the luminous efficiency value of that lamp. However, there are some factors that can cause changes in lamp efficiency. We can list them as follows;

- outdoor temperature,
- ballast specifications,
- lamp position,
- changes in mains voltage,
- usage time

The average lifetime of the lamp under standard operating conditions is called the lamp life. There are some features that affect the lamp life. Some of those;

- fluctuations in the mains voltage,
- powder,
- moisture,
- shake,
- on-off frequency,
- ambient temperature,
- used starter,
- ballast

At the same time, lamps are evaluated with their re-operation conditions, number of switching, network frequency distortions (frequency pollution).

3.1 Types of Lamps

3.1.1 Incandescent Lamps

Incandescent lamps are one of the oldest sources of electric light. Today, they are widely used because they are cheap and easy to install. Incandescent lamps flow current through a filament made of tungsten wire. They produce light with incandescent degree of reddening of the wire. Incandescent lamps spectrum creates a smooth and continuous radiation. Although their color rendering is high, they have very low light rendering. The reasons for this are high thermal losses and most of the emitted radiation is in infrared wavelengths. Incandescent lamps are affected by the mains voltage. The lamp life specified for these lamps is an average of 1,000 hours for 220V voltage and 1% mains fluctuation.

The biggest drawback of incandescent lamps is their low overall efficiency. 90% of the electrical power drawn is converted to heat power and 10% to light power. [16]. Due to the low energy efficiency, it is no longer produced. It even has banned the production and sale in EU countries. Saving lamps and led lamps are preferred instead of these lamps. The conversion rate of electric power to light power of led lamps is much higher. In short, incandescent lamps are not economical.

3.1.2 Incandescent Halogen Lamps

Halogen lamps have higher luminous efficiency and a whiter light than conventional incandescent lamps. Due to the high temperature of the halogen bulb, the bulb structures are made of smaller and heat-resistant glass. Halogen bulbs have an average life of 2000 hours

3.1.3 Fluorescent Lamps

It is mainly in the low-pressure mercury vapor lamp class. Phosphorus becomes light emitting as a result of ultraviolet. The purchase cost is higher than incandescent lamp. However, the luminous efficiencies of these lamps are 3-5 times that of incandescent lamps. It is one of the most popular light sources with advanced color options. Frequent switching on and off of lamps shortens their lifespan. They are affected by temperature differences. Their lifetime is 10000-20000 hours. They are suitable for illuminating places such as schools, libraries, offices.

3.1.4 QL Induction Lamps

QL induction lamps produce light by triggering the formation of a discharge in the mercury vapor of the induction coil. There is no conventional electrode or filament structure inside the lamp. Therefore, the lamp life is longer than other lamp types. QL lamps have an operating life of 60,000 hours. Most of the time they can produce 100,000 hours of light. Induction lamps have a long life and low maintenance costs. The inner wall of the lamp is covered with fluorescent powder. It can also be used indoors, as it has the color series in fluorescent lamps. It is suitable for industrial use. Induction lamps are not affected by mains fluctuations. The luminous efficiencies of the lamps are 70 lm/W and this value is considerably higher than other lamp efficiencies.

3.1.5 High Pressure Sodium Vapor Lamps

The lamp life is between 8,000-20,000 hours. Their luminous efficiencies are between 70-150 lm/W. Light spectrums are smooth but not continuous. They get hot while working. It gives 90% of the light efficiency between 2-5 minutes. Re-ignition requires a period of 2-5 minutes. It has the feature of being dimmerable. They work in a horizontal position. They do not produce harmonics. Usage areas: Road lighting, Lighting of platforms and vehicle parks, Lighting of industrial areas, Lighting of sports facilities, Lighting of exterior parts of buildings

3.1.6 High Pressure Mercury Vapor Lamps

In addition, the light spectrum of the high-pressure mercury-vapor lamp is concentrated at certain wavelengths (yellow, green, blue, purple), and red light is not produced. Therefore, the inner part of the outer bulb is covered with a phosphor layer to reduce the color rendering of the lamp. The lifetime of high-pressure mercury vapor lamps is approximately 20,000 hours and their power is 50-1000W. The luminous flux is 1.800-58.500 lm. Color temperatures are in the range of 2,900-4,200 °K.

Usage areas: Illumination of rural and urban areas, Illumination of mineral deposits and quarries, Illumination of public buildings such as schools, train stations, official offices, Lighting of steel - paper mills

3.1.7 High Pressure Metallic (Metallic Halide) Lamps

Most of the light is provided by the high-intensity discharge from the radiation of the metal vapor and halide mixture. Their lifespan is 6,000 – 7,500 hours. Frequent switching on and off adversely affects lamp life. Color temperatures are 3000 – 5600 °K. The luminous flux is 19,000-200,000 lumens. If the lamp is operated at excessive power, its life will be shortened. Its light turns blue at low power. A quality light cannot be obtained. Because they are very close to daylight, they are used in photographic and film lighting, sports shows. It provides economy in stadium and television studios lighting. It gives bluish white light.
Usage areas: Illumination of shops, showcases and museums Indoor lighting for decorative purposes Projector applications of historical artifacts and building surfaces Illumination of sports activity areas Illumination of ports and construction areas Illumination of industrial exhibition areas and hypermarkets Illumination of high and partially covered areas.

3.1.8 Lighting with Fiber Optic Cables

There are numerous solutions offered by fiber optic cables in the field of lighting. In general terms, fiber optic lighting; It is the transportation of the light obtained from a light generator to the desired area via fiber optic cables carrying light. Fiber optic lighting systems have differences from traditional lighting systems. these are the remote positioning of the light source and the transport of the light by fiber cables.

3.1.9 Light Emitting Diodes

It is a technology that has a very wide application area that will leave traditional lighting systems behind soon. It has many features such as very low energy consumption, high luminous efficiency, minimal dimensions, wide color range, different color temperatures. It has a fast light output in the order of nano seconds. It is resistant to shock and vibrations. It does not contain fragile elements such as glass, filament. Since LED bulbs use direct current, their operation is completely silent. It is environmentally friendly; It does not contain heavy metals such as mercury and halogen gases in its structure. Safe use is possible due to the cold light that does not give off heat.

CHAPTER IV

LIGHTING CALCULATION

Lighting Calculation for each venue; it is made in accordance with the way of use, area, geometry and required illuminance level. According to the result of the calculation, how many of the desired luminaires will be used, what its power will be and how it will be placed in the room are determined. The lighting technique covers the calculation methods necessary to provide an economical and quality lighting in a system. The average luminous intensity of the area to be illuminated is taken from the relevant table in accordance with the purpose of illumination. And with the help of other data, the most suitable luminaire and bulb type and quantity are calculated. The tables to be used in the Lighting Calculation are as follows;

- Reflection coefficients
- Room lighting efficiency
- Minimum illuminance levels
- Luminous flux table by lamp power
- Suspension (rod) length (tij)
- Contamination (maintenance) factor
- Luminaire types

Table4.1 Reflection coefficients of some important substances

Surface	Ref.Coeff. %
clean concrete	%40 - %60
clean whitewash	80%
off-white	%60-%70
bright aluminum	70%
matt aluminum	60%
window glass	8%
frosted glass	%10-%12
light yellow	%50-%70
light red	%20-%35

table 4.1 (cont.)

dark green	%10-%30
white	%70-%80
black	8%

Table 4.2 Room lighting efficiency

CEILING	0,8				0,5				0,3	
WALL	0,5		0,3		0,5		0,3		0,1	0,3
GROUND	0,3	0,1	0,3	0,1	0,3	0,1	0,3	0,1	0,1	0,1
room index $k = \frac{a.b}{(a+b).h}$	room efficiency									
0,6	0,24	0,23	0,18	0,18	0,2	0,19	0,15	0,15	0,12	0,15
0,8	0,31	0,29	0,24	0,23	0,25	0,24	0,2	0,19	0,16	0,17
1	0,36	0,33	0,29	0,28	0,29	0,28	0,24	0,23	0,2	0,2
1,25	0,41	0,38	0,34	0,32	0,33	0,31	0,28	0,27	0,24	0,24
1,50	0,45	0,41	0,38	0,36	0,36	0,34	0,32	0,3	0,27	0,26
2	0,51	0,49	0,45	0,41	0,41	0,38	0,37	0,35	0,31	0,3
2,5	0,56	0,49	0,5	0,45	0,45	0,41	0,41	0,38	0,35	0,34
3	0,59	0,52	0,54	0,48	0,47	0,43	0,43	0,4	0,38	0,36
4	0,63	0,55	0,58	0,51	0,5	0,46	0,47	0,44	0,41	0,39
5	0,66	0,57	0,62	0,54	0,53	0,48	0,5	0,46	0,44	0,4

Table 4.3 Contamination maintenance factor

Armature	Type of illuminance	Cleaning Time			contamination status
		1 Year	2 Years	3 Years	
Accor Lamp	Direct	- 1,35 1,65	- 1,55 2,15	- - -	low normal more
	Semi Direct	1,25 1,45 -	1,4 1,5 -	- - -	low normal more
	Mix	1,25 1,45 -	1,4 1,8 -	- - -	low normal more
	Semi indirect	1,35 1,65 -	1,55 2,15 -	- - -	low normal more
	Indirect	1,35 1,65 -	1,55 2,15 -	- - -	low normal more
Fluorescent Lamp	Direct	- 1,4 1,65	- 1,7 2,55	- 1,9 3,1	low normal more
	Semi Direct	1,25 1,45 -	1,4 1,8 -	1,55 2,06 -	low normal more
	Mix	1,35 1,65 -	1,55 2,15 -	1,76 2,5 -	low normal more

Table 4.3 (cont.)

	Indirect	1,25 - -	1,45 - -	- - -	low normal more

For a lighting plan drawings, certain calculations should not be made first. What type and how many will be placed in the selected area will be determined. The armature power, flux and intensity should be determined. The first thing to do for these programming should be strongly emphasized.

There is an EN 12464 standard. At the same time, Turkish Standards were accepted and published by the European Standards Committee (CEN).

The terms in these standards are given below;

- Lx: intermediate level
- UGRL: glare value
- Uo: smoothness of the illuminated surface
- Ra: color rendering

Table 4.4 Some EN12464-1 values [15]

	Type of areas, task or activities	Em	U0	UGR	Ra
General Areas	Circulation areas and corridors	100	0.40	28	40
	Stairs, escalators, travolators	100	0.40	25	40
	Elevators,lifts	100	0.40	25	40
	Loading ramps/ bays	150	0.40	25	40
Offices	Flying,copying, etc.	300	0.40	19	80
	writing, typing, reading and processing	500	0.60	19	80
	Technical drawing	750	0.70	16	80
	CAD work stations	500	0.60	19	80
	Conference and meetings room	500	0.60	19	80
	Reception desk	300	0.60	22	80
	Archives	200	0.40	25	80
Surfaces	Walls (in office)	75	0.10	-	-
	Walls (in other rooms)	50	0.10	-	-
	Ceiling (in office)	50	0.10	-	-
	Ceiling (in other rooms)	25	0.10	-	-

Table 4.5 Some TS EN12464-1 values [14]

Tablo 5.1 -Bina içlerindeki dolaşım bölgerleri						
Ref. No.	**Alan-Görev-Aktivite Türleri**	**lx**	**UGRL**	**U0**	**Ra**	**Özel Durumlar**
5,1,1	Koridor ve Dolaşım Alanları	100	28	0,4	40	Zemin düzeyinde aydınlatma Ra ve UGR, komşu alanlar için birbirlerine yakındır. Eğer güzergâh boyunca gölge yaratabilecek herhangi bir araç (ya da engel) varsa 150 Ix. Giriş ve çıkışların aydınlatılmasında, gündüz ve geceye bağlı olarak, iç ve dış mekânlar arasındaki ani değişikliklerden kaçınmak üzere ışık geçiş bölgeleri oluşturulmalıdır. Işıklandırma, cadde ve sokaklardaki sürücü ve yayaların gözlerini almayacak parlaklıkta yapılmalıdır.
5,1,2	Merdiven,yürüme bantları ve asansörler					Eşiklerde daha belirgin kontrastlar, uygulanmalıdır.
5,1,3	Asansör girişleri					Asansör kapısı önündeki ışık düzeyi en az Em = 200 Ix, olmalı.
5,1,4	yükleme rampaları					
Tablo 5.26 — Ofisler						
5,26,1	Dosya ve fotokopi odaları	300	19	0,4	80	
5,26,2	yazma, okuma ve veri işleme,	500	19	0,6	80	
5,26,3	teknil çizim	750	16	0,7	80	Işıklandırma kontrol edilebilir olmalı
5,26,4	CAD çalışma birimleri	500	19	0,6	80	
5,26,5	Konferans ve toplantı odaları					
5,26,7	Arşivler					
Tablo 5.33 — Kamu binaları – Genel alanlar						
5,28,1	Giriş salonları	100	22	0,4	80	Mümkünse UGR
5,28,2	emanet odaları	200	25	0,4	80	

Table 4.5 (cont.)

5,28,4	bilet ofisleri	300	22	0,6	80	
Tablo 5.36 — Eğitim öğretim amaçlı binalar-okullar						
5,36,1	sınıf ve uygulama odaları	700	19	0,6	80	Işıklandırma kontrol edilebilir olmalı
5,36,2	akşam dersi sınıfları	500	19	0,6	80	Işıklandırma kontrol edilebilir olmalı
5,36,3	oditoryum ve amfiler	500	19	0,6	80	Çeşitli audio/visual ihtiyaçlar için ışıklandırma kontrol edilebilmelidir.
5,36,4	kara,yeşil yada beyaz tahtalar	500	19	0,7	80	Speküler yansımalar önlenmelidir. Işıklandırma öğretmenin uygun açıda dikey olarak aydınlatılmasına uygun olmalıdır.
5,36,8	teknik çizim odaları	750	19	0,7	90	
5,36,9	laboratuvar ve uygulama odaları	500	19	0,6	80	
5,36,10	beceri odaları	500	19	0,6	80	
5,36,11	öğretim atölyeleri	500	19	0,6	80	
5,36,12	müzik odaları	300	19	0,6	80	
5,36,13	bilgisayar odaları	300	19	0,6	80	
5,36,18	merdivenler	300	25	0,4	80	
5,36,20	öğretmen odaları	150	19	0,6	80	

Lighting Calculation The following values must be determined for the lighting calculation; [13]

- The width of the room (a)
- Size of the room (b)
- Room height (H)
- Reflection coefficients of room walls: Ceiling, Wall and Floor colors. (Light, Medium Dark, Dark etc. like.)
- The distance between the luminaire and the surface to be illuminated (h): It is calculated by calculation.

- Working surface height: 0.85m.
- Illuminance level (E): It is determined from the table according to the purpose of use of the room.
- Rod length: It can be taken as 0.40 meters in lighting projects.
- Contamination factor (d)
- Lighting type: Direct, Semi-mast, Indirect, Semi-indirect, Freely Distributed lighting.
- Luminous flux of the luminaire to be used (Φ L): Considering the energy efficiency, it is determined from the appropriate table according to the power of the lighting device used.

The following method is generally used in a lighting calculation.

- Calculate the distance between the luminaire and the surface to be illuminated.

$$h = H - (0.85 - \text{Rod length}) \tag{4.1}$$

- Calculate the room index

$$k = \frac{a.b}{(a+b).h} \tag{4.2}$$

- Determine the lighting efficiency from the "Room Lighting Efficiency Table" according to the reflection coefficients of the room.
- Calculate the required total luminous flux.

$$\phi_T = \frac{1{,}25.E.A}{\mu_{AV}} \text{ (lumen)} \tag{4.3}$$

- Calculate the number of lamps required by dividing the total luminous flux by the luminous flux of the lamp to be used.
- Calculate the illuminance level to be realized according to the calculation.

$$Z = \frac{\phi_T}{\phi_L} \tag{4.4}$$

- Determine how the luminaires will be placed on the ceiling. In the placement of the lamps, a single luminaire is placed in the middle of the room, while in case of more than one luminaire, the distance between the lamps is twice the length between the lamps and the wall.

$$E = \frac{N.Z.\phi_L.\mu_{AV}}{1{,}25.S}(\text{lux}) \tag{4.5}$$

CHAPTER V

COLOR AND LIGHTING SYSTEM RELATIONSHIP

In the design of indoor lighting systems, which colors will be appropriate depending on the actions performed in the space and the effects of these colors on the lighting system will be mentioned.

Colors are effective on human psychology with their low or high vibrational energies. They have the power to deeply affect the emotional, mental and physical world of a person. It is necessary to examine colors in terms of psychology as well as structurally. While some colors are found to be narrowing and boring, some colors create a feeling of spaciousness and spaciousness on people. In addition, thanks to colors, an object can be perceived further away than it is, as if it were closer. Therefore, just like lighting, the use of colors creates an illusion in the human eye. [9]

Table 5.1 Recommended colors and effects in interiors

Place	Activity	Color	Psychological Effect	Light Color	CRI	Lighting System
Bedroom (Home, Hospital, Hotel, etc.)	Sleeping, Resting, Reading	Blue, Turquoise, Light shades of purple, Light green, Magenta	Comfort, rest, soothing, softening and calming	ww nw	2A	Dimmerable luminaires, ceiling reflective indirect lighting, bedside lighting
Wet Areas (Home, Hospital, Hotel	Washing, Shower, Make-up etc.	White and its shades, blue-turquoise, green	Purity-cleanliness, showing the spaces wider	ww nw	2A	Moisture and water resistant luminaires, glass

Table 5.1 (cont.)

Kitchen (Home, Hospital, Hotel, etc.)	Preparation, Storage, Cooking, serving	Green, Yellow and its shades	Reminiscent of nature, being safe and peaceful	ww nw	2A	Warm light colors Special lighting setups for countertops and cabinets
Living Room, Hall (Home, Hospital, etc.)	Sitting, Resting, Watching TV, Waiting	Light colors, White, Light Blue, Natural colors	To rest the eyes, to give peace, to relieve stress, to rest	ww nw	2A	Warm color lamps, indirect lighting, dimmable lighting or zonal lighting with warm light colors
Study Rooms (Office, Home, etc.)	work, meeting	Purple and light shades, Black and contrast colors, Navy	Providing concentration, providing authority, making you feel relaxed and unresponsive	ww nw	2A	Light should be provided from one direction, adjustable movable table lamp
Corridor (common areas)	waiting, passing, sitting	Rose, peach, Purple and light shades, etc.	Activating feelings of self-confidence, Giving peace of mind	ww nw	2A 3	Translucent sconces, wide angle luminaires
Children Room (Dance studio Rest.)		Orange Red Yellow Green Shades	Keeping attention, energizing, movement and vitality, accelerating blood circulation	ww nw	1 2A	Ceiling reflective indirect lighting Color and special lighting systems

CHAPTER VI

PROGRAMING with DIALux evo

6.1 What is DIALux evo

It is a free new generation computer application that is constantly updated for lighting design. It allows planning exterior and building planning, road lighting and lighting calculations of the existing AutoCAD project. It offers countless armature brands and varieties. With the design files of the world's leading manufacturers, the necessary luminaires for lighting design can be easily selected. Or the fixtures already in the DIALux library can be used. Examines the distribution of illuminance levels over the selected space. The application makes the necessary lighting calculations and quickly documents the entire project.

6.2 Lighting Account with DIALux Program

The level of illumination required is taken into account in the lighting technique. In addition to technical criteria, the selection of luminaires is made taking into account aesthetic criteria and necessary calculations are made to ensure an economical, high quality and sufficient illumination.

This feature of the program examines the role of daylight coming from the window at any time of the day in the lighting system. It offers options such as only daylight lighting, luminaire lighting with daylight or only luminaire lighting. Clear skies, medium skies, and cloudy skies are also selectable features. With the coordinate calculation, its location at any point in the world can also be selected. The unit of measure for luminous intensity - specifically in artificial light - is Lux (Ix). In indoor areas, daylight is given as %.[2].

This section describes a kind of home project made with the Dialux program. In this project, the lighting design of a detached house will be examined. There are 7 areas in the house that we will investigate. These will be studied under the titles of living room, kitchen, corridor, parent's room, children room, laundry and bathroom.

6.2.1 Luminaires

First of all, the luminaire suitable for the location is searched from the dialux library "LUMsearch". This library contains millions of fixtures from thousands of companies.

Figure 6. 1 Library steps

After these stages, you can filter your search according to power, flux, light color or many different features. The technical specifications of the luminaire used in this project are given in Figure 6.2 The documentation feature of the Dialux program provides easy access to the luminaires list. There are 5 different producers used in project. Also, same producer exists on different lm values because of area calculations.

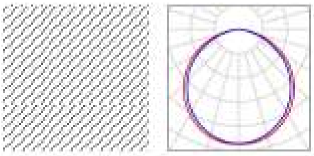
Φ_{toplam}	P_{toplam}	Işık verimi
70708 lm	728.6 W	97.0 lm/W

Adt.	Üretici	Ürün No.	Ürün adı	P	Φ	Işık verimi
20	LAMPTIME	230305	15W S.A. BACKLIGHT DOWN.	14.8 W	1559 lm	105.3 lm/W
4	LAMPTIME	230315	12W S.A. BACKLIGHT DOWN.	12.7 W	1672 lm	131.6 lm/W
8	LAMPTIME	230315	12W S.A. BACKLIGHT DOWN.	12.7 W	871 lm	68.6 lm/W
6	LAMPTIME	240452	36W 120cm 50*80 S.Ü LINEER ARMATÜR	33.1 W	2942 lm	88.9 lm/W
3	Thorn	96629027	CHAL 150 LED3000-830 HF RSB [STD]	27.2 W	2740 lm	100.7 lm/W

Figure 6.2 Technical specifications of luminaires

6.2.2 Living Room

The living room consists of 30.57 m^2. In this project, the lighting design was designed by taking into account the "Least illuminance levels table" and making improvements. Nominal value is 100lx. The technical specifications of the luminaire used in this design are given in Figure 6.3.



Üretici	LAMPTIME	P	14.8 W
Ürün No.	230305	$\Phi_{Işık}$	1559 lm

Figure 6.3 Luminaire part list

It used 12 LAMPTIME luminaires. Project calculation is 268lx. Measured total power value is 177.6 W and total flux is 18708 lm. The energy flux density is 5.81 W/m^2. This room has a luminous efficiency of 105.3 lm/W.

The visuals of the lighting design made with this luminaire are given below.

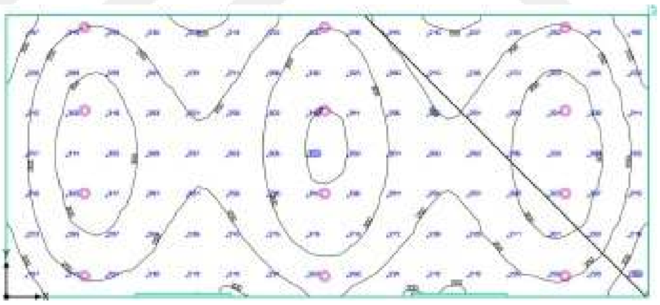


Figure 6.4 Work plane (living room)

Figure 6.5 Living room

Table 6.1 Usage levels of living room

Livingroom Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	Uo E_{min}/ E_{avg}
	150 lx	268 lx	357 lx	0.42

6.2.3 Kitchen

In this project, the lighting design was designed by taking into account the "Least illuminance levels table" and making improvements. The technical specifications of the luminaire used in this design are given in Figure 6.6. Kitchen consists of 32.84 m^2. It used 6 LAMPTIME and 3 Thorn luminaires. Measured total power value is 280.2W and total flux is 25872 lm. The energy flux density is 8.53 W/m^2. This room has a luminous efficiency of 92.3 lm/W.

Figure 6.6 Luminaire part list

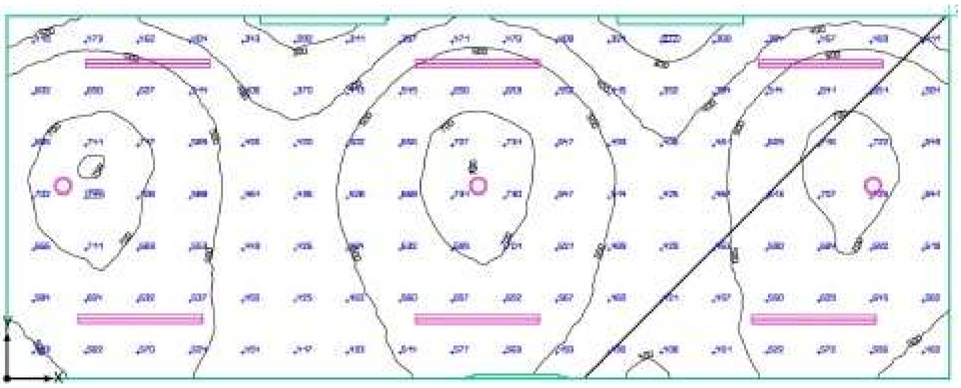


Figure 6.7 Work plane (kitchen)

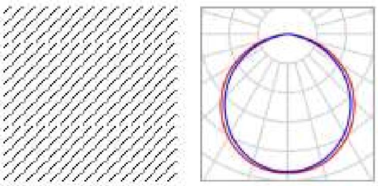
Figure 6.8 Inverted color representation of kitchen lighting design

Table 6.2 Usage levels of kitchen

Kitchen Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	**Uo** (E_{min}/ E_{avg})
	268 lx	541 lx	751 lx	0.50

6.2.4 Corridor

In this project, the lighting design was designed by taking into account the "Least illuminance levels table" and making improvements. The technical specifications of the luminaire used in this design are given in Figure 6.9. The corridor consists of 33.41 m^2. It used 4 LAMPTIME luminaires. Measured total power value is 50.8 W and total flux is 6688 lm. The energy flux density is 1.52 W/m^2. This room has a luminous efficiency of 131.7 lm/W.



Üretici	LAMPTIME	P	12.7 W
Ürün No.	230315	$\Phi_{Işıklık}$	1672 lm

Figure 6.9 Luminaire part list

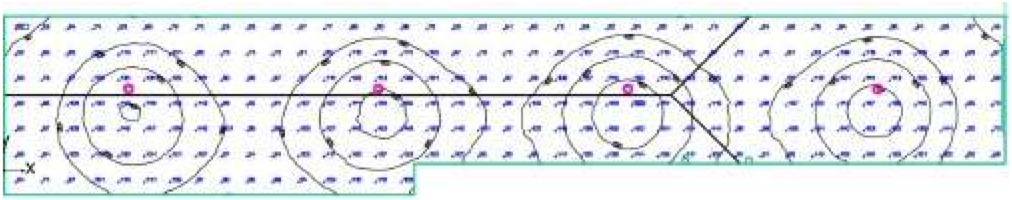


Figure 6.10 Work plane (corridor)

Table 6.3 Usage levels of corridor

Corridor Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	Uo (E_{min}/ E_{avg})
	12.7lx	104 lx	166 lx	0.12

6.2.5 Parents Room

In this project, the lighting design was designed by taking into account the "Least illuminance levels table" and making improvements. The technical specifications of the luminaire used in this design are given in Figure 6.11. The parents room consists of 25 m^2. It used 4 LAMPTIME luminaires. Measured total power value is 59.2 W and total flux is 6236 lm. The energy flux density is 2.37 W/m^2. This room has a luminous efficiency of 105.3 lm/W.

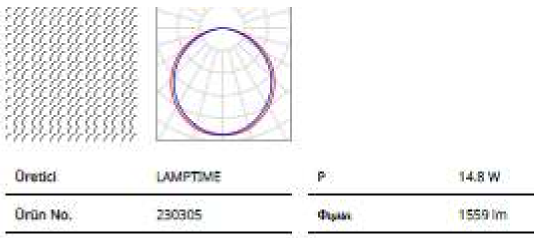


Figure 6.11 Luminaire part list

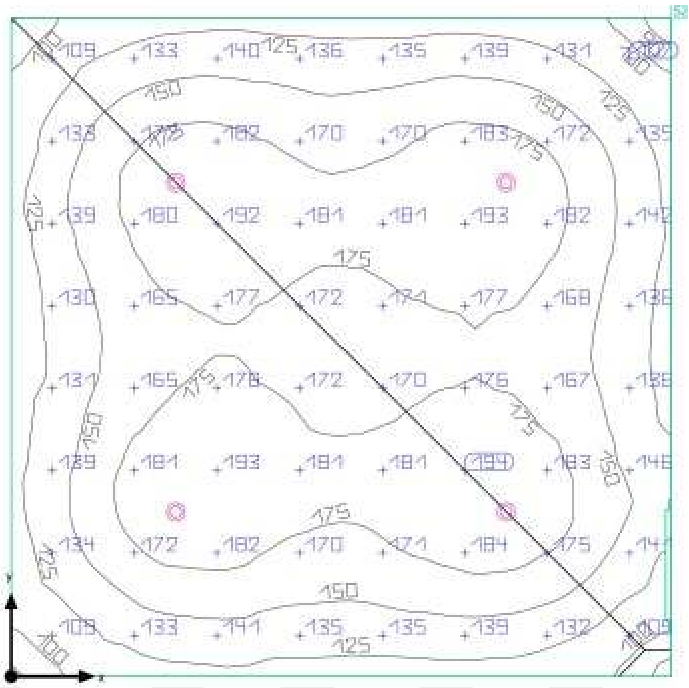


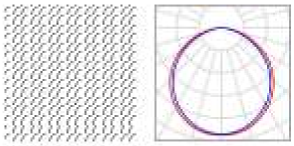
Figure 6.12 Work plane (parents room)

Table 6.4 Usage levels of parents room

Parents Room Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	**Uo** (E_{min}/ E_{avg})
	85.3 lx	157 lx	197x	0.54

6.2.6 Children Room

In this project, the lighting design was designed by taking into account the "Least illuminance levels table" and making improvements. The technical specifications of the luminaire used in this design are given in Figure 6.13. The children room consists of 22 m^2. It used 4 LAMPTIME luminaires. Measured total power value is 59.2 W and total flux is 6236 lm. The energy flux density is 2.69 W/m^2. This room has a luminous efficiency of 105.3 lm/W.



Üretici	LAMPTIME	P	14.8 W
Ürün No.	230305	Φlamba	1559 lm

Figure 6.13 Luminaire part list

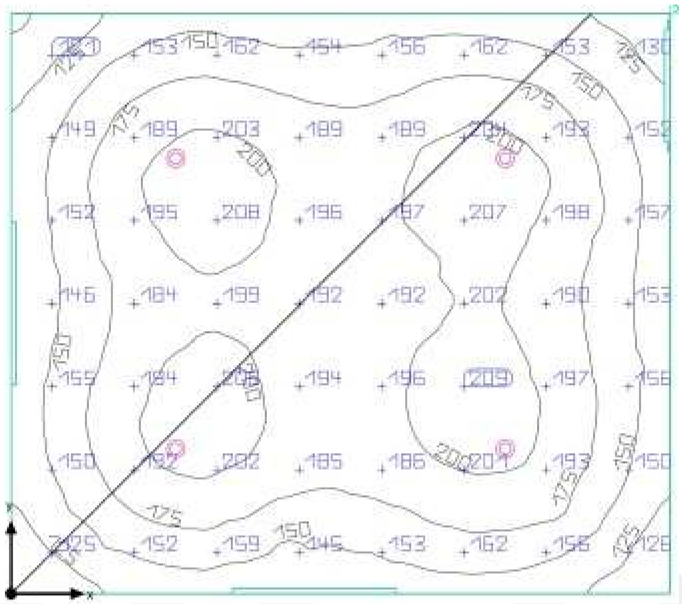


Figure 6.14 Work plane (children room)

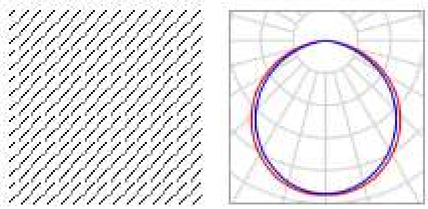
Table 6.5 Usage levels of children room

Children Room Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	Uo (E_{min}/ E_{avg})
	96.1 lx	174 lx	211 lx	0.55

6.2.7 Bathroom

In this project, the lighting design was designed by taking into account the "Least illuminance levels table" and making improvements. The technical specifications of the luminaire used in this design are given in Figure 6.2.7.1. The bathroom consists of 17.50 m^2. .It used 4 LAMPTIME luminaires. Measured total power value is 50.8

W and total flux is 3484 lm. The energy flux density is 2.90 W/m^2. This room has a luminous efficiency of 68.6 lm/W.



Üretici	LAMPTIME	P	12.7 W
Ürün No.	230315	$\Phi_{Işıklık}$	871 lm

Figure 6.15 Luminaire part list

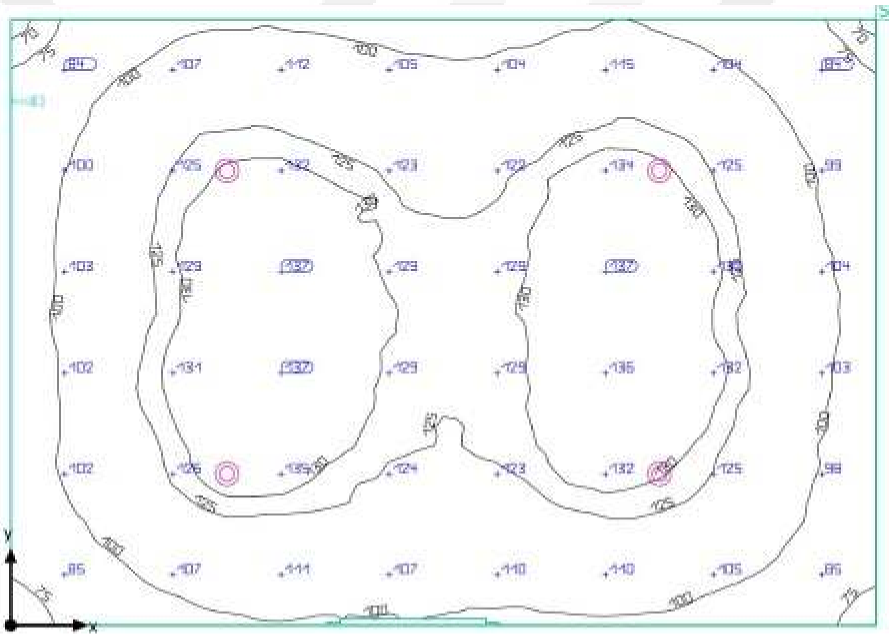


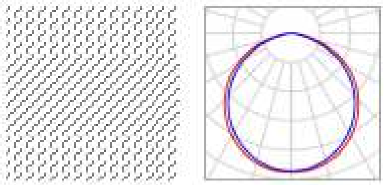
Figure 6.16 Work plane (bathroom)

Table 6.6 Usage levels of bathroom

Bathroom Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	**Uo (E_{min}/E_{avg})**
	68.5 lx	115 lx	139 lx	0.60

6.2.8 Laundry

In this project, the lighting design was designed by taking into account the "Least illuminance levels table" and making improvements. The technical specifications of the luminaire used in this design are given in Figure 6.17. The bathroom consists of 18.88 m^2. .It used 4 LAMPTIME luminaires. Measured total power value is 50.8W and total flux is 3484 lm. The energy flux density is 2.69 W/m^2. This room has a luminous efficiency of 68.6 lm/W.



Üretici	LAMPTIME	P	12.7 W
Ürün No.	230315	$\Phi_{Işık}$	871 lm

Figure 6.17 Luminaire part list

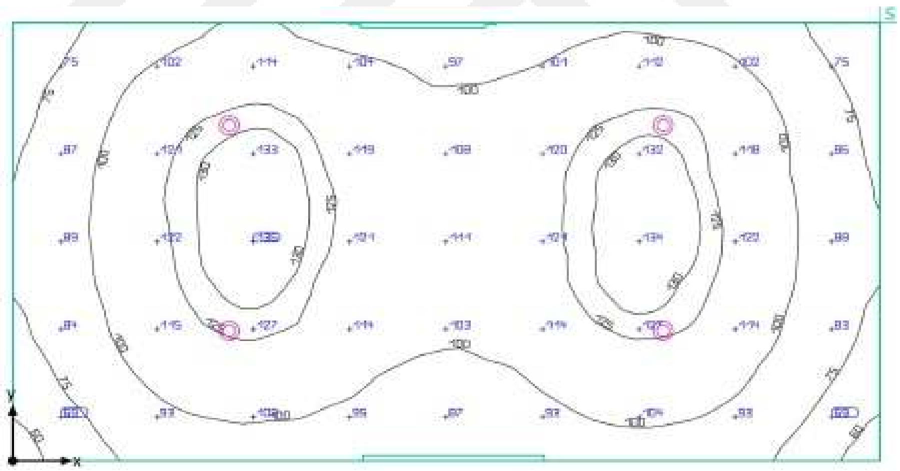


Figure 6.18 Work plane (laundry**)**

Table 6.7 Usage levels of laundry

Laundry Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	**Uo** (E_{min}/ E_{avg})
	55.7 lx	105 lx	135 lx	0.53

6.3 Evaluation of DIALux data

In this section, the effect of our dialux data on different luminaire and room features and homogeneous luminosity will be examined. This section will be examined in the living room.

First of all, the use of a different armature and work plane will be examined. If we make another calculation using different skylights; let's use another luminaire with led lamp feature. The technical specifications of the luminaire used in this design are given in Figure 6.19.

Üretici	WHITECROFT	P	8.4 W
Ürün No.	MEDIUM SEMI-SPEC	Φ	923 lm

Figure 6.19 Luminaire part list

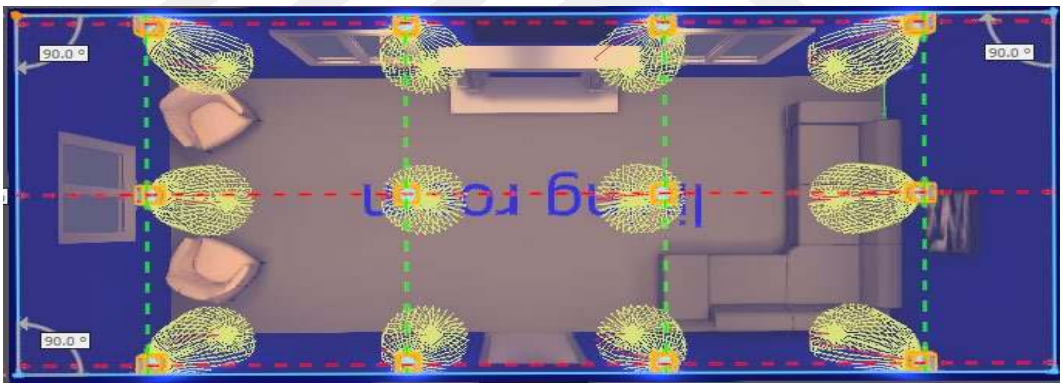


Figure 6.20 Ground view (living room)

As it can be seen;

i. by using 12 x 8.4W = 100.8 W lamps,
ii. than using 12 x 14.8 W = 177.6W lamps,
iii. We save 177.6 – 100.8 = 76.8 W energy.
iv. Luminous efficiency is 109.9 – 105.3 = 4.6 lm/W induced.
v. Energy consumption amount is reduced [280 - 340] kWh/a to [150 - 190] kWh/a.
vi. U0 reduced. Homogeneity of the light is reduced.

Table 6.8 Living room usage levels[I]

Livingroom Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	Uo (E_{min}/ E_{avg})
LAMPTIME	150 lx	268 lx	357 lx	0.56
WHITECROFT	79.7 lx	203 lx	268 lx	0.39

After the armature change, it continues with the wall color change. The current color of the living room is navy blue with the code 5002. and the reflection coefficient is 7%. Let's change this color traffic white with code 9016. The reflection coefficient of this color is 88%. Let's examine the measurement values realized with this change.

Figure 6.21 Living room with new color

Table 6.9 Living room usage levels[II]

Livingroom Artificial Lighting Measurement	E_{min}	E_{avg}	E_{max}	Uo (E_{min}/ E_{avg})
Code5002	79.7 lx	203 lx	268 lx	0.39
Code9016	146 lx	284 lx	359 lx	0.51

i. By using code9016 color (wth. %88) illuminance level is induced to 284 lx. And utility value(U0) is reduced.
ii. Measured total power value is 48 W and total flux is 4713 lm.
iii. The energy flux density reduced 5.81 to 3.30 W/m^2.

iv. U0 induced. Homogeneity of the light is induced and close to the initial value.

CHAPTER VII

CONCLUSION AND DISCUSSION AND SUGGESTION

It is thanks to the light that we can see the objects around us. Color is a concept related to perceptions. Objects appear in different colors by reflecting the colors on them at different rates. It is clear that colors have effects on human psychology. For this reason, the selection of colors suitable for actions in spaces is an important issue.

Considering that half of the brightness levels will be insufficient with an optimistic view, indirect/direct damages to large public communities can be estimated. In houses, for example, the lack of light in a living room makes it difficult to do all kinds of work such as reading books, newspapers, preparing school homework, sewing and embroidery, and small handicrafts. It is thought that dim light will increase mistakes, cause extreme fatigue, irritability and failure.[8]

On the other hand, since the level of illumination outside is not related to the temperature of the air, the expenses caused by the glass surfaces that are too large in cold places will be an unnecessary loss for the economy of the country. Considering the level of illumination in the interior in daylight lighting, two main conclusions can be reached;

I. Glass surfaces to be calculated with insufficient formulas may be either much larger than necessary or, on the contrary, too small.
II. Glass surfaces of the research to be performed on the optimum size of the country's meteorological, geological and social conditions are required to adhere to.

This project is a simple design of home lighting. A certain lux value was determined for each room and a design was made accordingly. It is an important factor that the light is distributed homogeneously to the environment and to the work surface.

The reflection coefficient of light is an important factor affecting the illumination. The color of the room or any object will be shaped according to the reflection coefficient and will definitely affect the luminous value. In the review section, a few changes in the living room were examined. First of all, the luminaire replacement and the skylight line were changed. The amount of W used has decreased, but the uniformity has also decreased. Then we changed the color of the room. As the lux value of the room increased, the uniformity value also increased and approached its original state. Considering these situations, when improvements are made, the electrical efficiency is increased by correctly positioning and changing the luminaires. In addition, the desired U0 value was achieved with color change. Thus, the desired minimum illuminance levels are obtained and less electricity consumption is provided.

It is necessary to make some efforts to improve the lighting conditions in our buildings and especially in residences. Small illustrated brochures and handbooks should be prepared for the public to use. Among them, information should be given that will help each citizen to improve their current situation with their own means. In the long term entail positive results of these efforts.

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