LIGHTS & SHADOWS

THE IMPLEMENTATION OF ARTIFICIAL LIGHTING IN ARCHITECTURE

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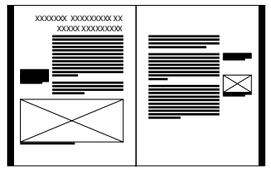

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LIGHTS AND SHADOWS
The implementation of artificial lighting in architecture

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Final Degree Project
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Escola Tècnica Superior d'Arquitectura del Vallès
Universitat Politècnica de Catalunya

Dedicat a totes les persones o éssers inanimats que heu estat allà,
en algun moment, ajudant-me per fer aquest treball.
En especial:
Ylènia - Francesc - Marta - Cristina - Joan

I a les persones que malauradament ja no ho podran veure
Mama

Moltes gràcies a tots

FOREWORD

Over the years, university studies have given great importance to natural lighting but less to artificial lighting, although it is also of great importance in the world of architecture.

Whether it is an academic work or a project to be implemented, the projects focus on lighting as a normative issue, i.e. it is compliant with the stipulated regulations. Therefore, the firm does not go into why it is done, how it is to be represented and how that lighting will affect in the architecture as a whole - as it does with natural lighting - but it is reduced to the calculation of lighting and not the study of all the possibilities that artificial light can offer in the design of a building.

FIG.1 - Interaction of Light and Shadows

From here, and over the years, I have noticed how architects treat this question and how it transmits unique, personal and indescribable sensations. For this reason, I decided to make this Final Degree Project a collection of solutions which I have been working on about the ways in which artificial lighting can be used and how these variations can transmit different sensations.

Therefore, this Final Degree Project is a study to see how over the years artificial lighting has been integrated into architecture in order to understand how it can improve our spaces.

"Architects usually have an intuitive understanding of light and the best ways to use it in their designs, but they do not have a sufficient understanding of the building science involved in designing natural and artificial lighting devices for their buildings". [1]

[1] Claude L. Robbins
Daylighting Design and Analysis
Van Nostrand Reinhold, 1986

LUZOMBRA. LA LAMPE
Carlos Fortes (2007)

The play between light and shadow works like the sound and silence in a song, on the one hand there are the elements that transmit the message, and on the other hand, those that allow us to understand it.

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AIM OF PROJECT

The aim of this Final Degree Project is to **analyse** the different ways in which architecture has used **artificial light.**

Studying how throughout history the use of **technology has changed** and, consequently, how architects have introduced it in their projects and how this technical **evolution** has interfered in the way **buildings have been illuminated** over the years.

Classifying the processes in how architecture uses these methods so that the ways in which **lighting is applied** in different works can be extrapolated, as well as to establish a thesis of the different ways in which a space can be illuminated.

METHODOLOGY

In order to achieve the objectives set out previously, a specific methodology has been defined:

A first **introduction to light**, both the more scientific part, to be able to understand all the technical concepts that are explained to the work, and the more compositional and evolutionary part of natural lighting itself, to see how architecture has introduced the light in its buildings.

The second part is based on the **introduction to lighting,** with a bibliographical review to determine how artificial light has changed over the years and how architects have introduced it into their projects, as well as its constant evolution.

The third part is an a**nalysis of different projects in which artificial lighting is used intentionally** to create specific atmospheres and to analyse the methods used so as to arrive at some general conclusions about light in architecture.

INTRODUCTION

Humans in a constant luminous field where the incidence of light is crucial to define our lives. The human eye is the best sensor that has ever been created and it transmits everything we perceive. Lighting is and will be the means by which we perceive our environment and, therefore, no aspect of our lives can be perceived without it.

Architecture cannot be understood without lighting, which has always played a key role in the conception of the space we are looking to design. Therefore, it could be said that it is looking for the perfect balance between lights and shadows. According to Le Corbusier in Vers une architecture [TOWARDS AN ARCHITECTURE], "Architecture is the skilful, rigorous and magnificent play of volumes under the light".[2]

[2] LE CORBUSIER.
Hacia una Arquitectura, Barcelona: Ediciones Apóstrofe, 1998, p. 25

FIG.2 - Chapel Notre Dame du Haut. Ronchamp | Le Corbusier (2007)

Architecture has always been connected to light, trying to find the intentionality to generate the atmosphere that the space requires. Although sometimes the light is so integrated in our mind that it is forgotten to be a necessity, in reality it is an indispensable component. Therefore, we can say that light is one of the most important factors in any architectural project.

Natural lighting, that is to say the one that comes from the sun, is not enough to illuminate all the spaces and at all times, either because half of the hours of the year its radiation does not reach us, or because of the shape of the spaces and their openings, which cannot cover the whole set. In the face of this fact, humanity has been looking for solutions to solve this difficulty. This is how artificial lighting in architecture was born.

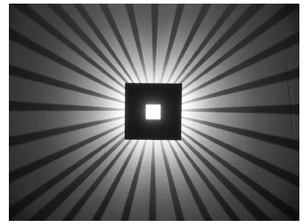


FIG.3 - Shadow effect

In this way, this work pretends to approach from an analytical point of view the application of artificial lighting in architecture and how it can develop a key role in the conception of spaces, considering the artificial element as a supplementary element to shed light in places where it is not naturally present and it becomes a defining element of architecture.

"Where there is light there is also shadow.
Will I stop loving light because it produces shadows?"

Heinrich Lübke 1921

THE THEORY OF THE LIGHT

HAGIA SOPHIA. Istanbul | Isidore of Miletus (537)

THE PROPERTIES OF LIGHT

Before discussing the application of lighting in architecture, it is important to establish some concepts to understand what light is, because sometimes its intangibility makes it difficult to understand the magnitude of what we are talking about. As a general concept, light is the visible part of the electromagnetic spectrum.

Electromagnetic waves are part of the same electromagnetic field where we can find ultraviolet rays, X-rays, gamma rays and even the radio waves that bring terrestrial television into our homes. The difference between them is defined by their frequency and wave length, and of this wide range we can only visibly see a small part -between 380 nm and 780 nm- with the human eye, which is called the visible spectrum. There are also other parts that are perceived by other senses, such as hearing, and that are received as audible frequencies and are comprised between 17 metres of wave and 17 mm, or what is the same, between 20Hz and 20 kHz.

[3]LIGHT
Light or visible light is electromagnetic radiation within the portion of the electromagnetic spectrum that is perceived by the human eye. [1] Visible light is usually defined as having wavelengths in the range of 400–700 nanometres (nm), corresponding to frequencies of 750-420 terahertz, between the infrared (with longer wavelengths) and the ultraviolet (with shorter wavelengths).
Wikipedia

[3] NANOMETRE
one thousand-millionth of a metre. (0.000000001 m)
Collins dictionary

[4] FREQUENCY
frequency, in physics, the number of waves that pass a fixed point in unit time; also, the number of cycles or vibrations undergone during one unit of time by a body in periodic motion. A body in periodic motion is said to have undergone one cycle or one vibration after passing through a series of events or positions and returning to its original state. See also angular velocity; simple harmonic motion.
Encyclopædia Britannica

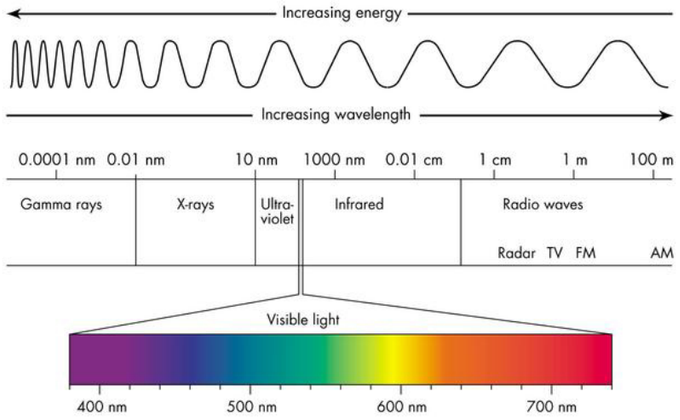


FIG.4 - Electromagnetic Spectrum

This peculiar aspect of light means that, since the times of Ancient Greece, humanity has wished to know how this concept works as it behaves in a completely unusual way to the other part of the radioelectric spectrum, since light can be given in the form of a compact particle and/or a wave, which is why it is called a photon[5].

Light[2] is described as radiation that propagates through space in the form of electromagnetic waves. These waves tend to fragment based on their wave amplitude (A), which is determined by the distance between the centre of the sinusoidal wave and the peak, which is measured in metres. Usually the frequency measured in hertz (Hz) is used, which is a ratio between the speed of light (C) in vacuum [299 792 458 m/s] and its wave length (λ). This wave length is the measured distance in nanometers (1 nm = 10-9 m) between the two crests of the sinusoidal wave, and therefore determines the frequency. Apart from these two magnitudes, another important factor is the amplitude of the wave (A) which is measured in metres

When this part of the visible spectrum is reflected onto an element, it causes it to absorb all of a portion of the visible wavelength spectrum that we see of the light. The portion of frequencies it absorbs causes us to perceive the object of a particular color. In the case of white, it reflects all frequencies and, therefore, their conjunction results in white. As for black, it absorbs them all and, therefore, nothing can be seen. On the other hand, in the case of water, despite being transparent, when the photon particles pass through it, it absorbs the frequencies that determine the red color and, therefore, the result of the reflected colors is the bruise (complementary color of red).

FIG.5 - The different colour temperatures, diferents percepcions

[5] PHOTON
A photon is an elementary particle that is a quantum of the electromagnetic field, including electromagnetic radiation such as light and radio waves, and the force carrier for the electromagnetic force

LIGHT AS THE MAIN ASPECT OF ANY ARCHITECTURE

Trying to understand architecture without lighting is just as impossible as trying to understand artificial lighting without considering natural light and the first of all the photon-emitting sources we have. Visible energy from the sun is the basis of any architectural design. As Louis I. Kahn said, "The sun never knew how great it was until it struck the side of a building"[6] and, for this reason, I will first explain a little bit in depth about exterior light, a concept that is present in any project indistinctly, even without being aware of it. Consequently, it is important to start by talking about natural light, sunlight, exterior light and the different definitions they have to do with.

[6] 1953 Louis Isadore Kahn (1901-1974) Kuressaare

Light allows us to know where we are and to see what surrounds us, but beyond the descriptive content, it can be said that light is responsible for shaping objects and helps us to conceive the world within a three-dimensional reality. Light makes us see the elements with their total volumetry, because it is not only a game of darkness and light, but all the shades between these two that perfectly define the spaces.

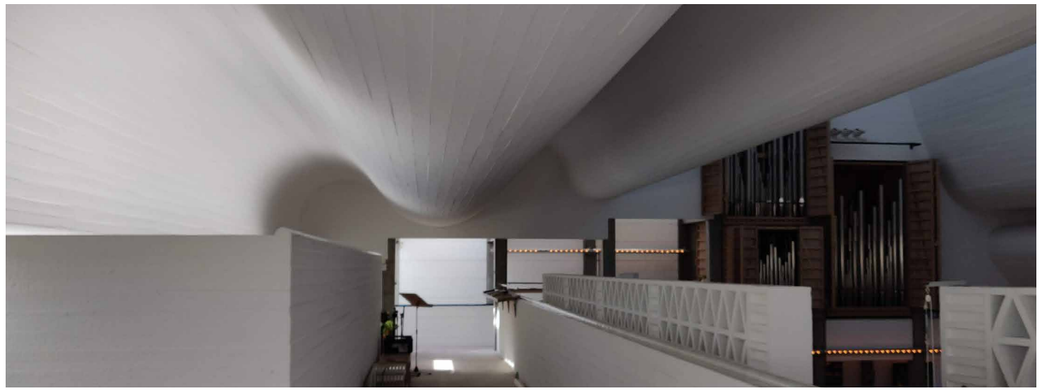


FIG.6 - Bagsværd kirke. København | Jørn Utzon (2019)

In the outdoor space, where the sun floods everything, it is only the elements themselves that create the magic and interact with each other to create light and shadow. In contrast, when we move inside, it is the architect who, through the openings, manipulates light to paint the surfaces and give them the desired atmosphere. This light is determined through the openings, made in any of the exterior envelopes of the space, which are called windows.

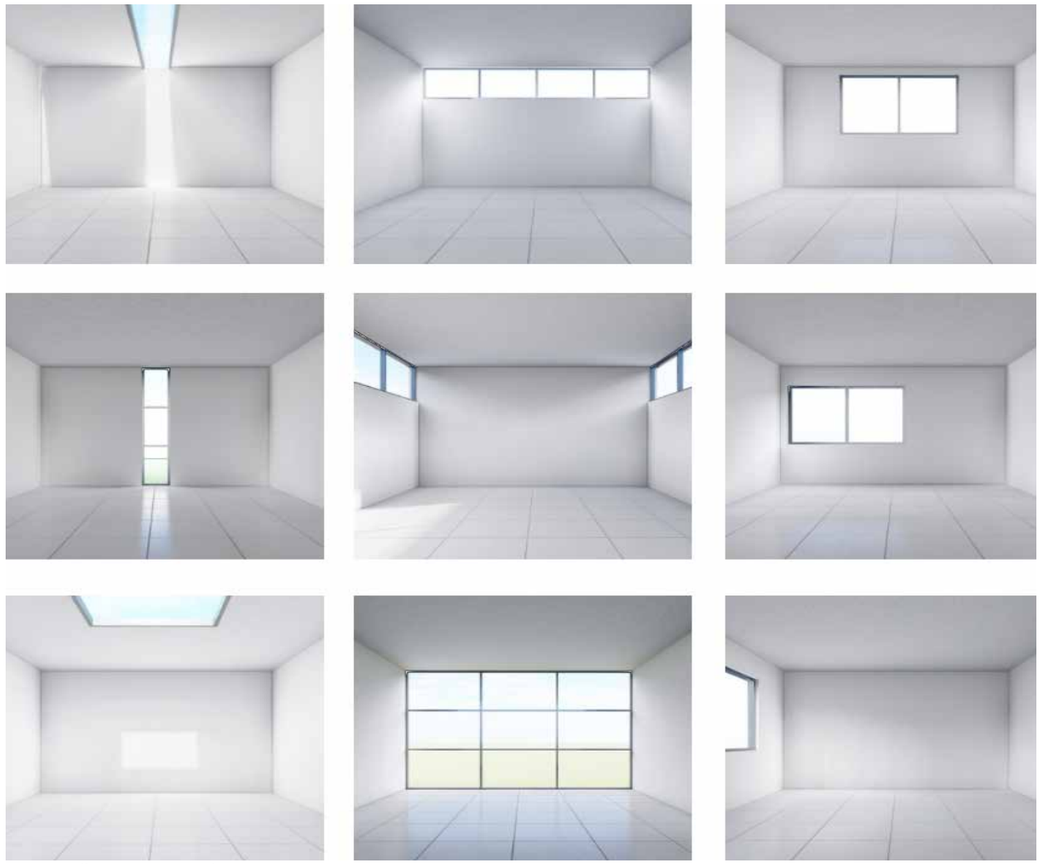


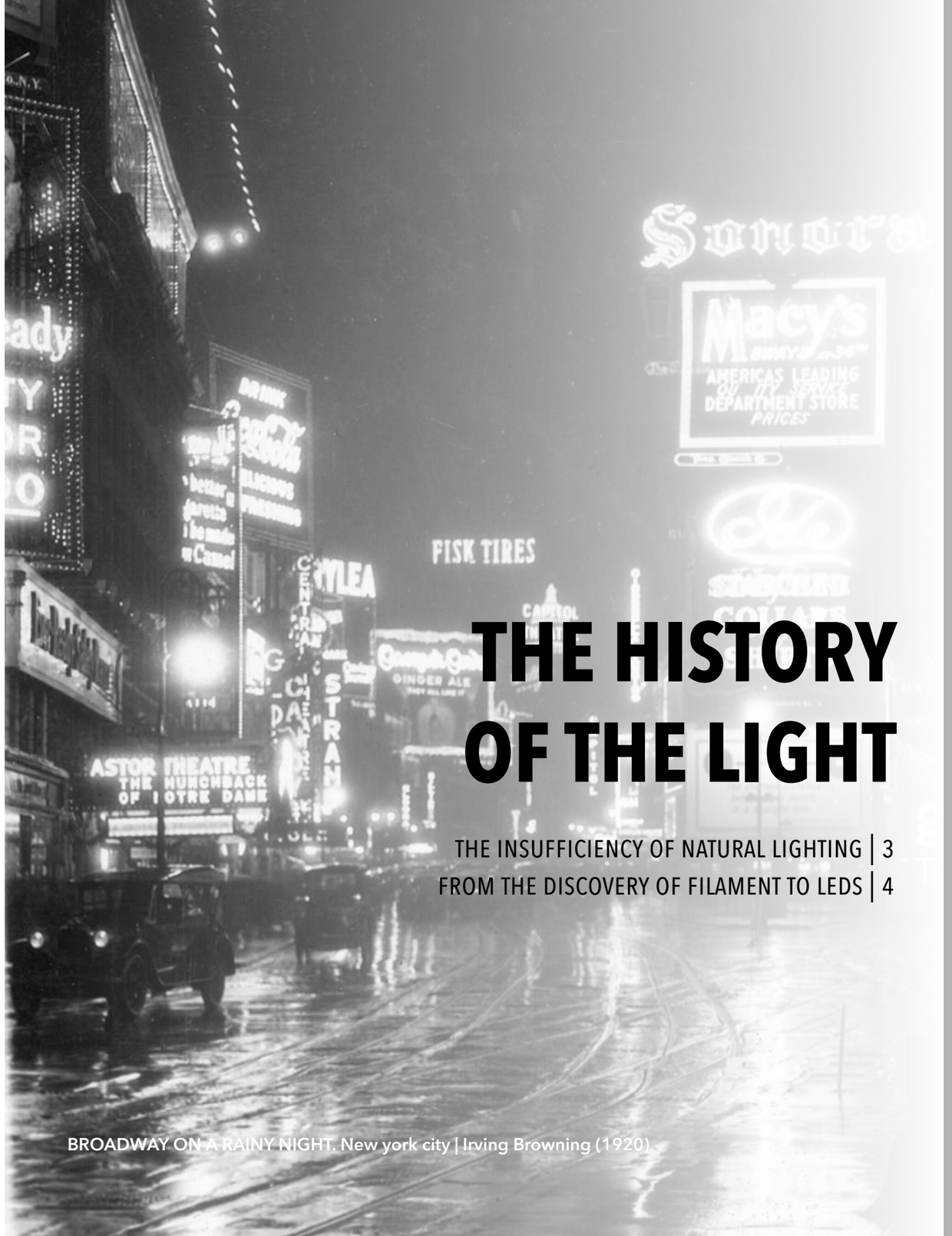
FIG.7 - Different variants of light entry

FIG.8 - The colour of light in architecture.
World Trade Center PATH Station

These openings in the interior space, which are called "windows" in common argot, make it possible to create a unique relationship between the exterior space and the interior. This affinity is not only one-way, but bidirectional in all the factors that act on it. In contrast, one tends to think that light enters the interior space through the window, but a building can also illuminate the exterior space from the inside. Apart from the relationship between light, the visual communication between the inside and the outside can generate many interactions.

Openings give us a different lighting experience depending on their location, size, angle of incidence and the direction of the sun over the days and months. Added to this are the climatic conditions of each moment that make the light unique for each situation, causing an emotional and intangible value in each individual on the architecture.

This value of light is due to the significance of a metaphysical value that is hardly palpable, even though it is not materially perceptible, its presence can be sensed through its projection on the elements of a space. Lighting is fundamental in establishing the relationship between humanity and its surroundings. Whether it is artificial or natural, the use of light tries to highlight the materials that the architecture employs through texture, colours and form, all helping to understand the space from a complete base, generating a particular atmosphere. When used in the right measure, it creates unique and indescribable experiences between the individual and the environment.



THE HISTORY OF THE LIGHT

BROADWAY ON A RAINY NIGHT. New york city | Irving Browning (1920)

THE INSUFFICIENCY OF NATURAL LIGHTING

Artificial lighting has allowed us to develop our lives without depending excessively on sunlight, and this has been a great step in the evolution of society, since it is now possible to carry out all kinds of activities at any time.

FIG.9 - Scene representing the way of lighting of the roman empire

When we talk about artificial lighting in this context, we usually think of electricity as the initial element, but mankind has been using artificial lighting for thousands of years. The control of light - according to experts - is one of the "discoveries"[7] that have best explained the development of the human being and a key point, as, apart from the lights, it allowed the development of human activities during the night.

[7] Price, David. «Energy and Human Evolution».

Fire was the first of the elements that we understand as artificial illumination, in 125 000 BC, and it can be established as the beginning of the artificial lighting science. In the beginning, in primitive times, wood or other inflammable materials were used to create torches that could be lit. This fact, apart from allowing illumination, was a great step forward when it came to generating heat, as combustion gave off heat.

FIG.10 - Roman lamp

As for illumination at night, torches continued to be important until the Middle Ages, as they were very easy to use anywhere. Even though the Roman lamps or lamps had already been used for many centuries, they were part of everyday life at the time. However, because its main fuel was olive oil, it was especially used in high society, as it was necessary to decide whether to burn olive oil for the lamps or for cooking.

This is already considered as the appearance of the first lamps, the element that includes the source of illumination made up of the metal and a recipient in which to keep the oil made of terracotta and which dates from 7000 to 8000 BC. From that time onwards, the concept was maintained with different supports such as bronze or iron, and with decorative elements.

FIG.11 - Torch

Although oil lamps continued to be the main source of illumination, in the following centuries new forms of illumination appeared, such as candles. The first ones were covered by beeswax as a fuel, and in the 18th century the so-called "whale oil"[8] was developed. This oil is also known as candela[9] and gives its name to the unit of measurement of the luminous quantity, which is used as a reference from the light emitted by burning this oil.

FIG.12 - Candels

[8] Whale oil is oil obtained from the blubber of whales.

FIG.13 - Argand lamp

Over the years, artificial lighting continued to evolve. Important in this evolution was the year 1782, when the Argand lamp appeared. This element used oil instead of animal fat. Even though, at that time, candles were still widely used as petrol was much more expensive. This was the case until the discovery of the paraffin in 1858, when the traditional candles were no longer used for economic reasons, and paraffin was used until the arrival of gas.

Gas lamps were very popular at the beginning of the 19th century, especially for street lighting, which had been nonexistent until then. This fact was due to the ease with which they could install them and supply gas throughout the city, which at that period derived from coal. The use of gas lamps was not extended beyond street lighting due to the lack of safety of gas combustion, although over the years the technology evolved to become a suitable source for indoors.

[9]The candela is the base unit of luminous intensity in the International System of Units (SI)
Wikipedia

FIG.14 - Gas lamp

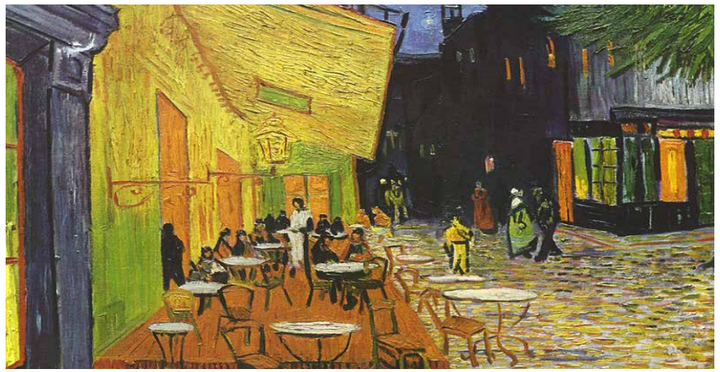


FIG.15 Café Terrace at Night Otterlo - netherlands | Vincent van Gogh (1888) - Oil on canvas

Gas marked a time that is very much reflected in painting, due to its great intensity in public illuminated spaces, as a result of its characteristic colour when it burns, in contrast to the night and the sky.

FROM THE DISCOVERY OF FILAMENT TO LEDs

The great revolution in lighting came in 1879, when the first bulb designs allowed electric current to pass through a filament, which was originally made of carbon. As technology improved, this filament was made of tungsten, which emitted light when heating up with electric current Subsequently, it was implemented with a glass capsule to prevent the material from oxidising and therefore degrading quickly.

Electricity, in reality, was not a new phenomenon, but it was already known back in Ancient Egypt. The problem, however, was that this electricity wore out the filament when it was heated up. But it was not until the end of the 19th century, after James C. Maxwell[11] determined how to control electricity, that electric lighting of houses and streets became popular, because it was more practical and easier to apply than previous technologies.

[11]TIn 1865, the Scottish physicist James Clerk Maxwell formulated the classical theory of electromagnetism, deducing that light is made up of electric and magnetic fields that propagate through space, a theory that led to the prediction of the existence of radio waves and radio communications.

Later, the glass capsule bulb was replaced by an "inert" gas and later by a halogen gas, which gave its name to halogen lamps. These lamps, however, are now banned for domestic use due to their low efficiency, because most of the energy is given off as heat.

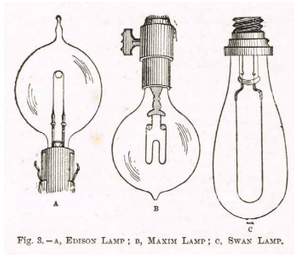


Fig. 3.—A, Edison Lamp; B, Maxim Lamp; C, Swan Lamp.

FIG.16 - Diferents types of lamps

Despite the great evolution of the filament, this source of light was still unidirectional around it, that is to say, it radiated light from an emissor at the centre to all around it, without being able to control the directionality of the light, but it began to be a key element to what we now know as artificial illumination.

One of the characteristics of light was that it could not be controlled, as the only thing that could be done was to turn it on or off with a switch. Thus, industry developed different

ways to attenuate/reflect this light by putting a cover around it in order to get different functions. These lamps could already be used to reflect a whole part of the light towards the direction in which it was needed to illuminate, as well as to diffuse the light through translucent elements.

FIG.17 - Diferent types of Light fixture

FIG.18 - Fluorescent lamp

FIG.19 - LEDS

From the 1960s onwards, a whole series of artistic evolutions started that varied according to the current that was influencing at the time. But the fact remains the same: an element that juxtaposes us with the point of light so as not to dazzle us and to diffuse the brightness that it may cause.

The discovery of the fluorescent bulb in 1934 and its use allowed us to improve efficiency and integration in architecture, due to its low emission. But it was not until the advent of LEDs, light emitting diodes, that the scene changed completely, not only because of its versatility compared to other technologies, but also because of its low consumption and its ease of adapting to any type of public space. Although this evolution dates back to 1960, it was not until the 2000s that it was fully implemented in architecture and therefore in our lives.

CASES OF STUDIES

WOOLWORTH BUILDING. Manhattan | Cass Gilbert 1913

5 CASE STUDIES

Lighting is usually defined as "enough light, where you want it, how you want it"[12]. But lighting must not only consider the fact of being seen, but also the emotions it creates and the connection it generates between humans and the illuminated architecture, whether artificial or natural. Although light has been much studied over the centuries, it has some intangible aspects that cannot be quantified in numbers but only in feelings. These emotions are the differentiating factor that make humans perceive differences between them and conceive the way to get involved and be in harmony with the generated architecture.

[12]Philips, Dereck, Lighting in Architectural Design McGraw Hill, 1964, p.45.

FIG.20 - Torre agbar | yann kersalé (2000)

For this reason, I wanted to describe three parameters that can determine the whole conception of lighting that can be had, such as theatricality, as a presentation of space, atmosphere, the intentionality that one wishes to give it and the integration that the lights have within the architecture.

As a consequence, and considering that any perception is not quantifiable but very personal and intangible for each individual, I have chosen five case studies in which artificial lighting has played a key role in that particular architecture, improving it and highlighting it at night. Moreover, I have been able to appreciate it first hand. Therefore, the works have been chosen through an essential factor: that I have been able to perceive those intentions that were aimed at in the design in situ, and where the design of the lighting plays a key role in the visual conception of that building. However, studying the visual conception of the space through images can lead to a distance between the spectator and the created work that does not define the scene very well.

The works are varied, in order to be able to see the different ways of integration and the conception they generate in the building, as well as the elements they have conformed.

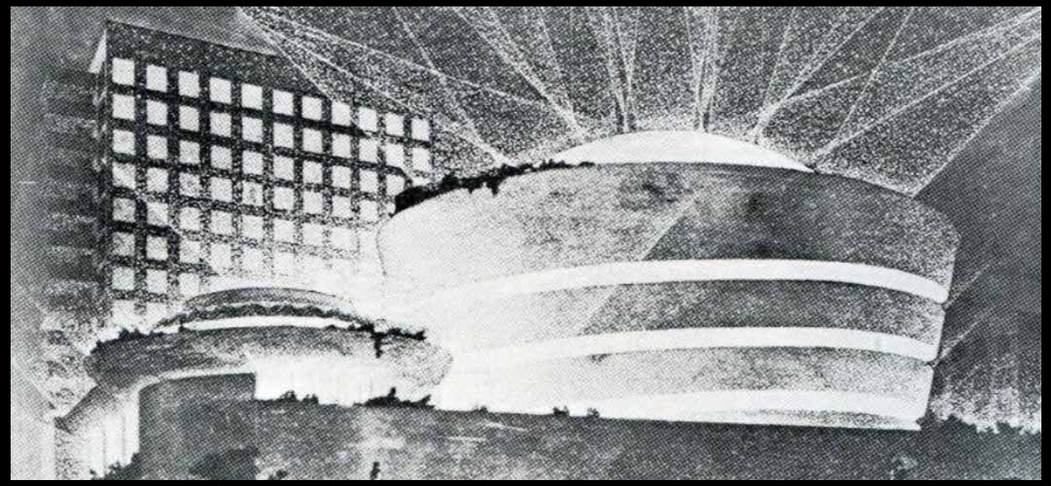


FIG.21 - Museum Guguenheim, New York skecht F. LL. Wright 1945

CASE STUDY 01

BAGSVÆRD KIRKE | København

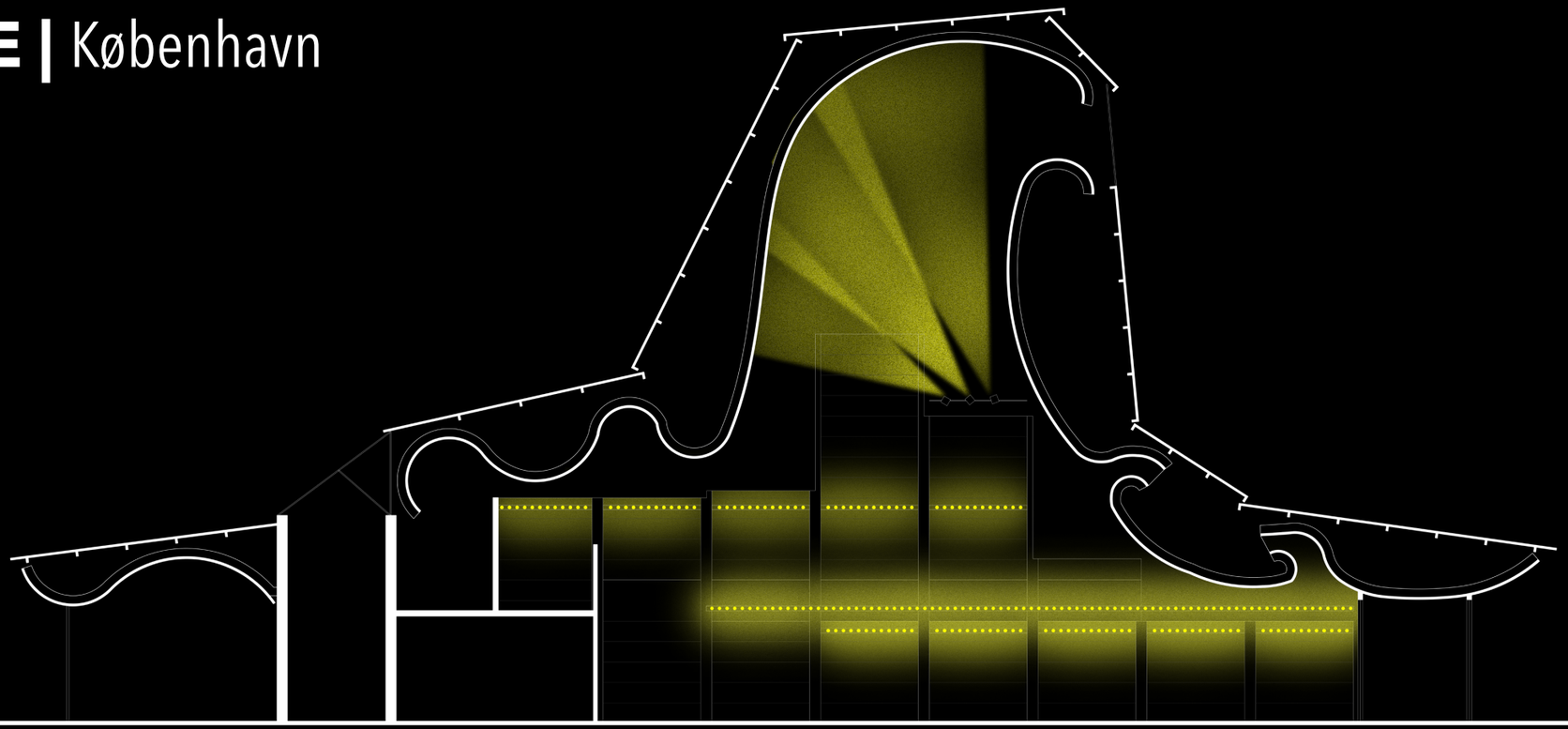
1976 - Jørn Utzon

The Lutheran church designed by Jorn Utzon is a great example of maximising the use of lighting in latitudes close to the poles. At the same time it is a constant virtue in this work, located in Copenhagen. The practicality of the envelope hides a large game of indirectly illuminated surfaces that collect the light right up to the altar *(FIG 301)* and where the zenith captions are maximized.

But when the natural light disappears, the architect proposes a game of filament bulbs anchored to a beam, as if in a constant rhythm *(FIG 301A)*. These bulbs are notable for their low colour temperature (2300o K) and where they are juxtaposed with the low cold light input during the winter months.

The constant rhythm between bulbs is symmetrically established in the side corridor of the first and ground floor (FIG 201C), where the light game is insinuated between the pillars, generating shadow spaces that are made up for by a second linearity of lights attached to the plan of the main nave. This creates a very warm atmosphere in a space where white is the protagonist *(FIG 303D)*.

Subsequently, spotlights were installed to illuminate the false ceiling and its curvatures to better capture the light, since the central areas were dark and thus indirectly provided more light in the space.



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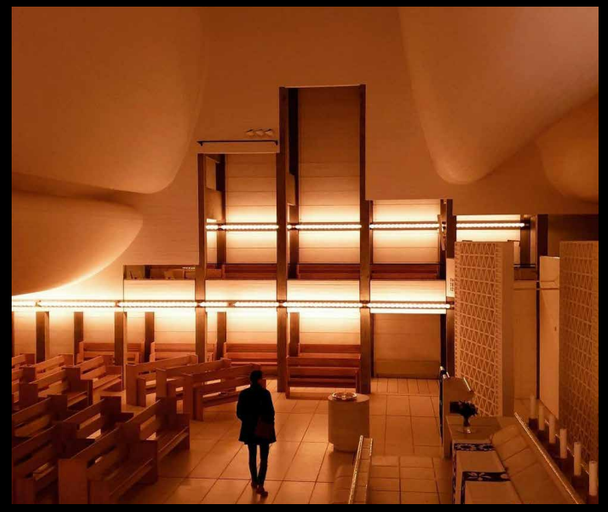

Fig: 301A | View of the central hall from the upper side passageway

Fig: 301B | View of the central shed from the altar

Fig: 301C | Lighting elements detail

Fig: 301D | Lighting elements

CASE STUDY 02

METRO STATIONS | Washington

1972 - Harry Wasse

Another example of the importance of artificial light is to be found in the Washington D.C. metro. It breathes the same monumentality as all the buildings that accompany it on the surface. Washington D.C. is a city that was designed for institutions and the metro could not be left behind.

The stations of what is the most important communication infrastructure in the city, designed by Harry Wasse, transport the user in a large elliptical cavity where the combined game of interlocking voussoirs in the form of coffers supporting the structure *(FIG. 302.A)* marks a repetitive but constant rhythm. These interlocking voussoirs mean that the interaction of light does not only occur in an elliptical plan, but also generates a combination of shadows, thanks to the indirect lighting.

This constant rhythm, combined with a linear light throughout, creates the impression that the station is floating inside the tunnel *(FIG 302B).* This is due to the fact that there are two symmetrical lines of light illuminating the voussoirs and generating a homogeneous light on the spectator, reinforced by a central line *(FIG 302C)* which is distorted by the passing convoys *(FIG 302D)* as if it were an indicator of their arrival.

This indirect lighting makes it impossible for there to be dark corners, but the illumination is constant, in rhythm with the structure and unalterable, where functionality overrides everything else.

Fig: 302A | Station access from the hall

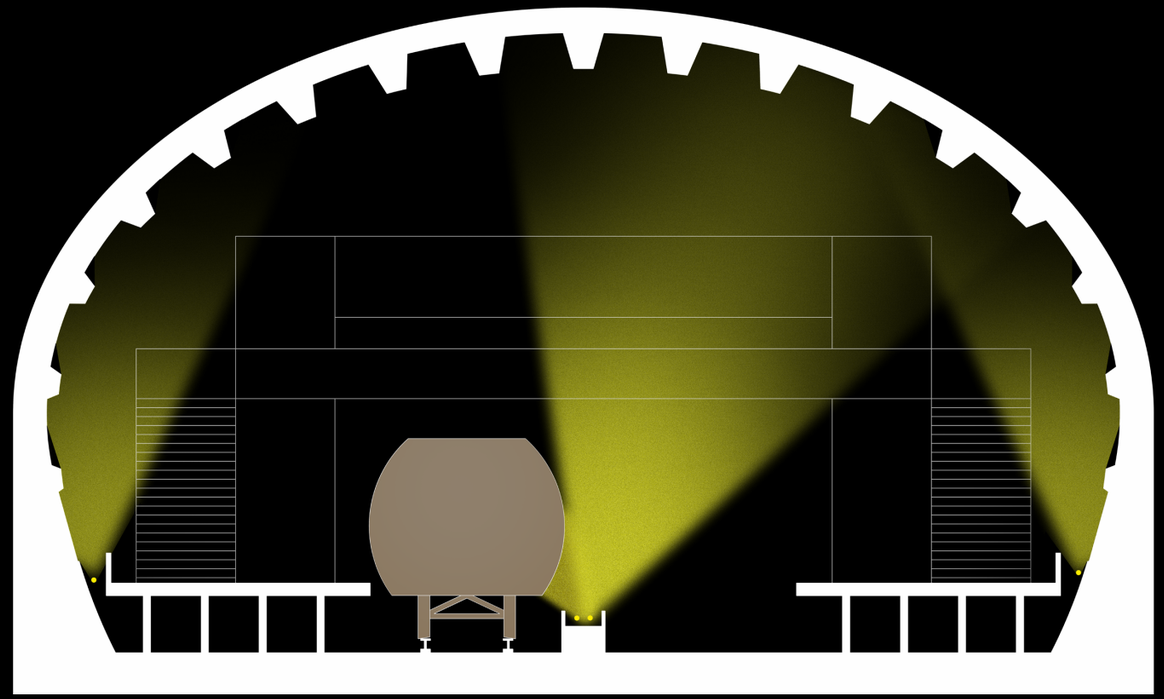

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Fig: 302B | Metro station without the train stopping

Fig: 302C | Light between metros

Fig: 302D | Metro station with the train stopping

CASE STUDY 03

SEAGRAM BUILDING | New York

1958 - Mies van der Rohe, Philip Johnson

The Seagram Building in New York is one of the buildings where Mies van der Rohe explores the rationality and practicality of his architecture with simple elements that become defining from the architecture generated. And in the lighting aspect it is no less so, since together with the lighting designer Richard Kelly, one of the pioneers of the treatment of light, is designed a lighting concept in which the light source is neither present nor visible, but rather it is the stained surfaces that bring the building to life.

The building treats the entrance and the offices on the back floors differently. At the entrance of the building, the strategy used is to stain with light all the kitchenware *(FIG. 303B)* where its materiality can be seen and gives a sensation of lightness as it is an open space from the street and where the light source is hidden in the false ceiling. This fact makes the walls themselves a sensation of brightness, since it looks like a canvas all stained.

This strategy is also used in office flats where the light source is a surface, in this case the false ceiling *(FIG. 303A).* There is only a substructure to support it, which interferes with an infinite sheet of illumination. This fact makes it perceptible from the outside that the building illuminates the exterior *(FIG. 303C)*, since during the day the exterior illuminates the interior.

As a curiosity, the illuminated surface was designed with an element with two intensities: one for working purposes and the other purely decorative for visual effects from the outside.

Fig: 303A | View from inside the office

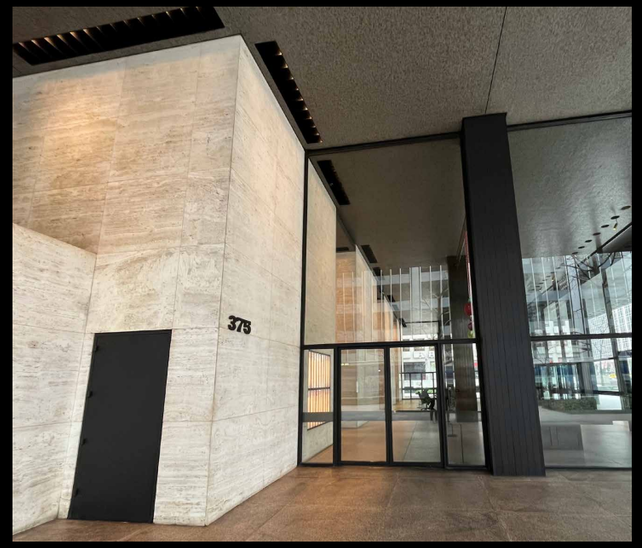
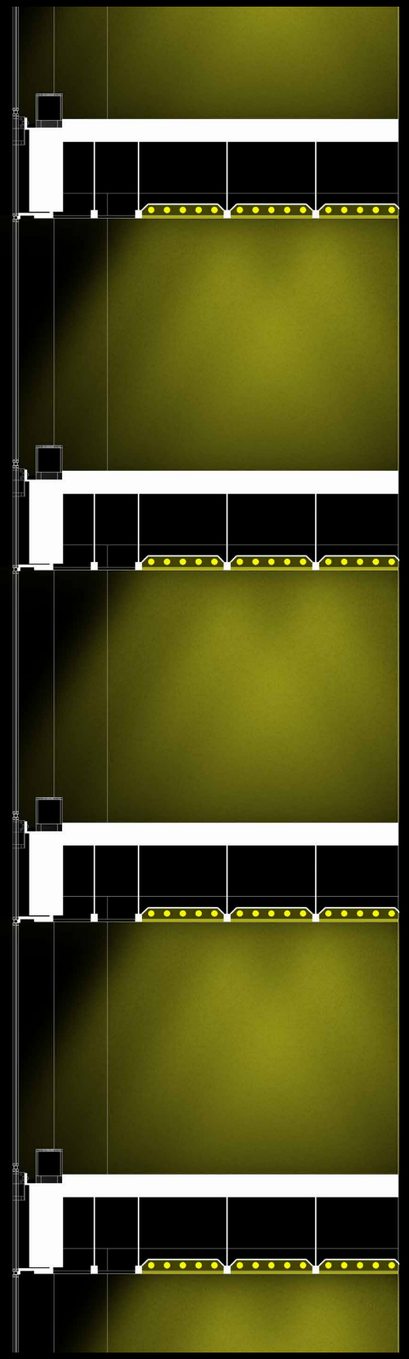


Fig: 303B | View of the lateral access to the hall, occult lighting fixtures paint the wall

Fig: 303C | View outside the building



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CASE STUDY 04

STANSTED AIRPORT | London

1991 - Norman Foster + Partners

The new terminal building, designed in 1981 by Norman Foster, follows the trend of the haig techology style that Foster had been using for some time in buildings such as the Bank of Shanghai (China) or the Renault distribution centre in Swindow (UK). The concept of seeking a union between architecture and technology, creating oly one volume supported by small structural domes distributed matrixially around the terminal.

Light is one of the fundamental elements of this roof, Foster leaves an aperture in the centre of the dome that allows light to enter, but not directly, but provides a latticework to mitigate the effect of the sun's reflection and spread the light around the roof, achieving a dim and moderate entry of light *(FIG. 304C).*

This fact is reversed at night, as floodlights embedded in the "pillars that support the roof" (and where all the services are embedded) project the light onto the roof. They project the light onto the roof, generating a harmonious and uniform reflection *(FIG. 304B),* preventing the lighting from being understood as a point of light, but rather as a continuous field of illuminated roof.

This communion between the light and the roof makes it an intrinsic part of it and generates a continuous illuminated field, only closed by a curtain wall *(FIG. 304A).*

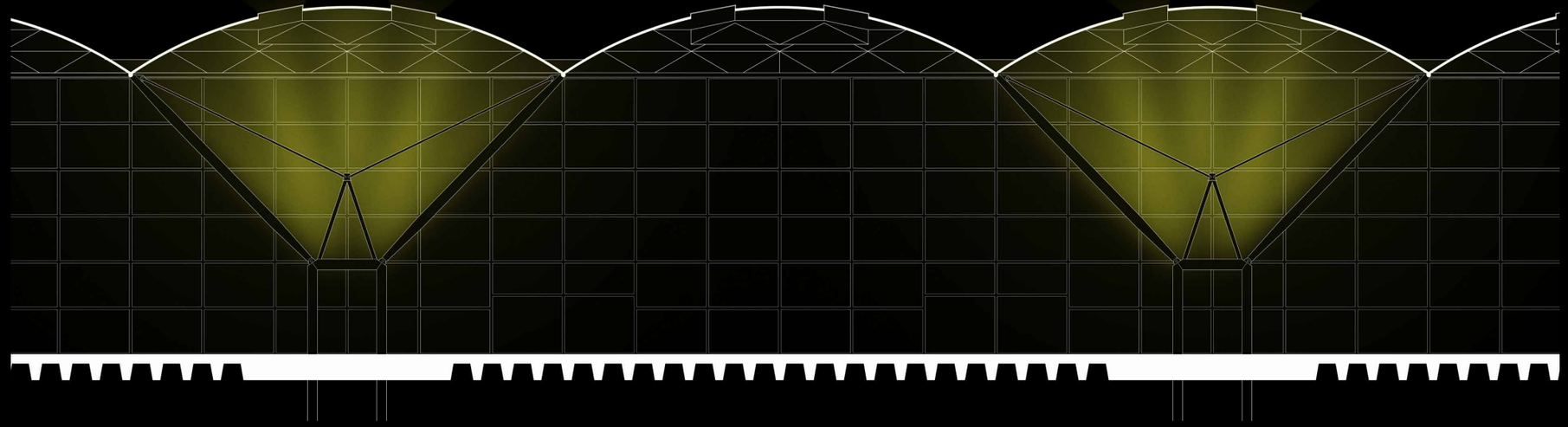

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Fig: 304A | View of the illuminated entrance porch

Fig: 304B | Interior view of the terminal

Fig: 304C| interior view of the estructure of terminal

CASE STUDY 05

JOHNSON WAX ADMINISTRATIVE BUILDING | Racine, Wisconsin

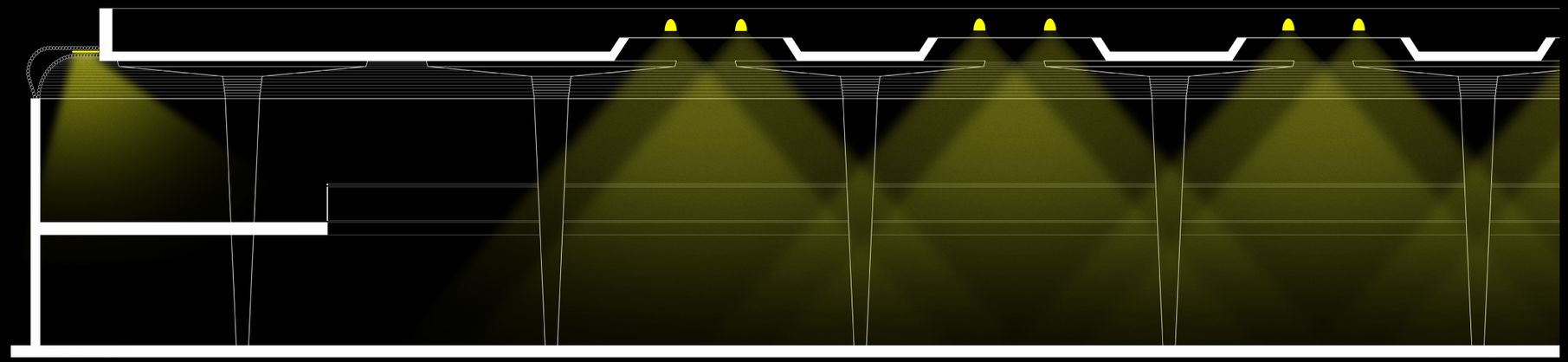
1936 - Frank Lloyd Wright

For the integration of natural light, the architect Frank Lloyd Wright uses zenithal light as the main support (fig. 305a), which filters between the pillars in the form of a forest of mushrooms. This zenithal light is also embedded through cylindrical tubes that help to diffuse and homogenize its luminaire *(FIG. 305C).*

This strategy of illuminating is also employed through artificial light, since it places the projectors outside these openings, to minimize the difference in light between night and day, since the providence of the human eye is the same in formal aspects. As if it were Alvar Aalto's Viipuri library (Russia), it takes advantage of every element by incorporating the same lighting *(FIG. 305E).*

This fact is also used on the sides of the offices, in a much more linear way where the lights are integrated in such a way that it seems that the light is always in the same way *(FIG. 305B).* This makes the building blend in at night and illuminates the building envelope at night *(FIG. 305D).*

In the areas where it is not entirely present, the openings camouflage the lights with the circular tubes so that the lighting is as homogeneous as possible with the rest of the openings.



E 1:100 | Section

Fig: 305A | Interior view the year of its opening

Fig: 305B | View of the lateral openings

Fig: 305C | View inside the offices

Fig: 305D | Outside view of the building

Fig: 305E | View of the light sources that are integrated in the building's zenithal solar windows

The shadow doesn't exist; what you call shadow is the light you don't see.

*Henri Barbusse*19

MUCH MORE THAN JUST ILLUMINATING

LUMINOUS SCENEGROPHY. Navacles | Carles Serrano 2021

LIGHT: MUCH MORE THAN JUST ILLUMINATING

Natural light has always meant much more than illuminating our lives. Since prehistoric times, civilizations have contemplated lighting as an indescribable fact, celebrating rituals around it and taking into account the lights and shadows it generates. From Roman times onwards, we can say that it developed a capital role, creating another element within architecture, as well as developing a combination that over the centuries has taken shape.

Therefore, it could be said that light generates a specific atmosphere that determines the values that architecture has to transmit. To synthesise concepts, the most determining factor that light needs is the spectator, and the spectator is the one who needs it to see the space. This constant symbiosis creates a unique link between the space and the moment with the spectator.

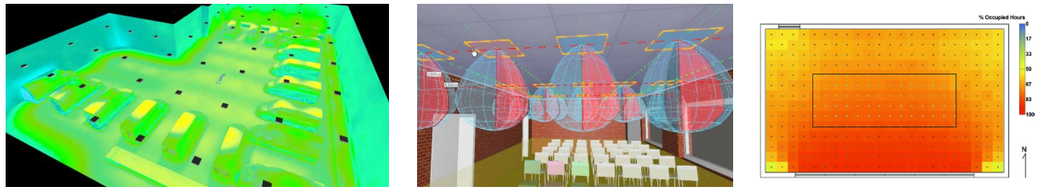


FIG.22 - Dialux diagram (quantitative)

Many of the projects consider lighting as a quantitative element, where the lighting calculation program (dialux or others) establishes whether the quantity of light (LUX)[13] established by the software is sufficient to comply with the law. Besides, normally this software suggests ways in which to put certain luminaires in order to make them more efficient and to comply with the law. The fact is, however, that the light must not only be a quantity, but also the quality of that space. Here is the reason for this work: must the quantitative element be overpowered by the quality?

[13] LUX
a unit of illumination, equivalent to 0.0929 foot-candle and equal to the illumination produced by luminous flux of one lumen falling perpendicularly on a surface one meter square
Collins dictionaries

In order to determine the constant value of such a subjective element as it is the quality of light, I wanted to catalogue three strategies that help to make good lighting of the space. These are theatricality, atmosphere and integration.

Firstly, theatricality, which is determined as the way to achieve the desired purpose through light, affects the way in which the architecture is illuminated and is very similar to the conception that a theatre lighting designer would have. This light is created to transmit specific emotions for each spectator. The same goes for architecture: artificial light has to be designed to transmit as if it were a stage lighting design.

The second strategy is the atmosphere. This is everything that encompasses a space and where light plays a key role in achieving its magnificence. So that a space has a specific and wished atmosphere, it has to take into account all the elements that are necessary and that include its totality.

And thirdly, there is integration, which tries to see how to integrate the two previous elements within architecture with the technological evolutions of the moment to ensure that the architecture shines under that light.

In summary, a combination of these three elements combined because the light set inside a space provides the spectator with an environment in which to develop their functions as a human being and the architecture does what any art generates, that is to say, to trigger emotions.

THE STAGING OF LIGHT: THEATRICALITY

The application of electricity to lighting elements at the end of the 19th century was a revolution in both control and safety of lighting, allowing it to be implemented everywhere. This made it possible to develop lighting creativity beyond the fact of seeing and being seen. This allowed the search for the most aesthetic and artistic content that would enhance the architecture without leaving behind the content for its creation, which is the fact of being seen in the dark.

As if it were a play, light has become a source of artistic creation in itself. It is no longer only that element that brings light to the darkness, which may or may not be more integral to the architecture, but it has become architecture in itself, without taking into account the adjacent elements.

Speaking in theatrical language, the scenes aim to transport the spectator to another reality, far from the space where it is consumed. By using the appropriate resources such as scenography, light, atmosphere, and smells, we can move to the space where the author wanted that moment to be represented. With artificial lighting applied to architecture, we have to try the same thing, that it is the protagonist of the space and that it cannot be understood in the same way without it.

Just as in a theatre, the light is configured and accentuated in order to expressly fit into that moment. In architectural lighting, light sources have gone from being an element of utility to an element of intention. The imperious intentionality of placing the points of light in specific places and making a specific type of light is thought and carried out in order to transport the spectator to that unique and unrepeatable moment as if it were a play.

This theatricalization of light is not new in architecture. In fact, natural light has been controlled for millennia to give theatricality to spaces. What is more modern is the application of artificial lighting in architecture, since, until the advent of electricity, the source of light was a purely practical purpose to improve human lives. There were buildings where the lighting elements were already being intentionally projected (burning fire). Due to the inability to control these elements, one cannot speak in the same way in terms of lighting to architecture compared to today.

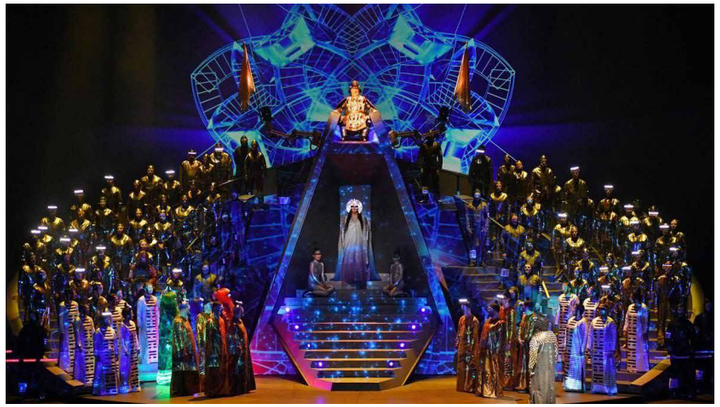


FIG.23 - TURANDOT | Liceu - Barcelona 2019

In a certain way, the inability to fully control the lighting did not allow a direct relationship. As with the scenic elements, the light source was an element that simply accompanied the text and sets. At that time, the light source was constant and came from the same place, and even if actors moved to another scene, this light continued to dominate. The control of light made those lights to be moved to the point of doing what everyone wants them to do, which is to be at the service of the scene.

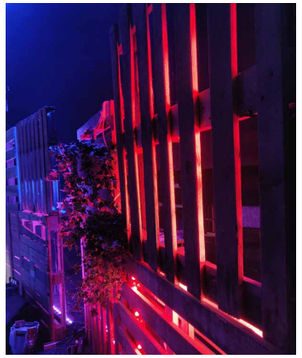


FIG.24 - Play with light, colors and textures

Back to architecture, electricity allowed light-emitting elements to be installed in the most unlikely places. In order to ensure that this light projection generated the desired atmosphere, and together with the application of the concepts of optics that were already well-developed at that time, it was possible to project light more clearly.

This artistic development of light has changed completely with the ease that LED technology has brought to architecture, reducing the heat source of the emitter and coming to consider the minuscule size of the emitting source of radiation. In this way, they have helped to develop the artistic concept of lighting technology in a completely different way, making a great leap towards making light the centre of attention, since light is now considered an art in itself, just as architecture can be.

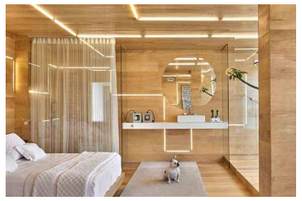


FIG.25 - The light remark the arquitectonic elements

Therefore, thanks to technology, architecture has to seek the same concept as stage lighting, which is still the purpose of any lighting: to see and to be seen, but with the added bonus of triggering emotions, of creating this quality of light, since the sum of these correctly lit and synchronised environments determines the proper functioning of a space, creating a specific atmosphere.

THE CREATION OF A PLACE: THE ATMOSPHERE

The atmosphere[14] is that layer that surrounds the earth and that makes us unique as a planet. In a certain way, it is what we try to achieve with architecture, to integrate all the elements that describe that space called architecture. Atmosphere is a heterogeneous concept to define, but one of the elements that Peter Zumthor[14] defines in "Atmospheres: Architectural Environments. Surrounding Objects" is how light interferes between things.

FIG.26 - Termas de Vals | Peter Zumthor

Light is one of the most influential factors in built architecture, allowing the perception of volumes, colours and materials, influencing the conception of space. Whether it is natural or artificial, light has to transmit a space conception and feelings. The difference between natural and artificial light control is that the former is easily controllable with the basic mechanisms that any architect can use, such as openings and intermediate elements to achieve the wished illumination. On the other hand, artificial light sources often have so many parameters to control that using all of them correctly requires a specialisation that few can achieve.

13Atmosphere talks to an emotional sensitivity, a perception that works at an incredible speed and that human beings have in order to survive. *Peter Zumthor (2006)*

14Peter Zumthor
(Basilea, april 26th 1943) architect

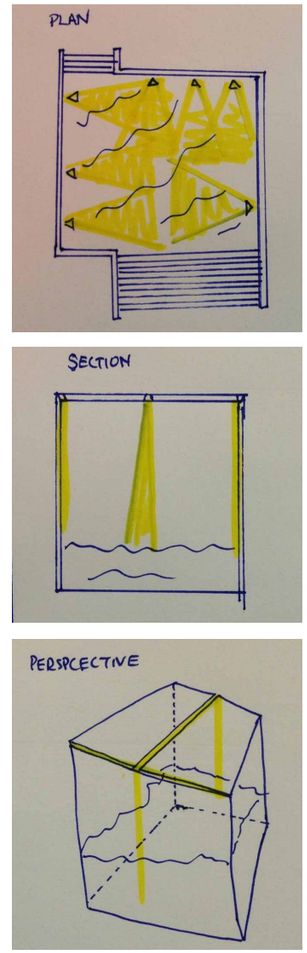


FIG.27 - Termas de Vals light diagrams

The control of these elements and all the characteristics that they bring are very technical facts that this work does not involve, but rather the fact of how to use them correctly to generate the atmospheric set that encompasses all the elements of a space and that the qualitative value of the light is decisive to achieve an aesthetic and unique value that makes you feel the light at a precise moment.

Within the world of the study of lighting and its effects on humans, the lighting designer Richard Kelly[16] is one of the pioneers in the implementation of lighting as an artistic element, and he considers the quality of light to be always more important than its quantity. Kelly developed light by working alongside the great architects of the time, such as Philip Johnson, Louis Kahn, Eero Saarinen and Mies van der Rohe.

16 Richard Kelly (1910–1977)
lighting designer

This fact gave Kelly a great deal of experience, and he continued to study light through the play of light and shadow to help define a joint atmosphere in his spaces, combining it with interfering objects. Kelly said that the lighting needed to define a desired atmosphere in architecture is made up of three elements: ambient luminescence, focal glow and play of brilliance.

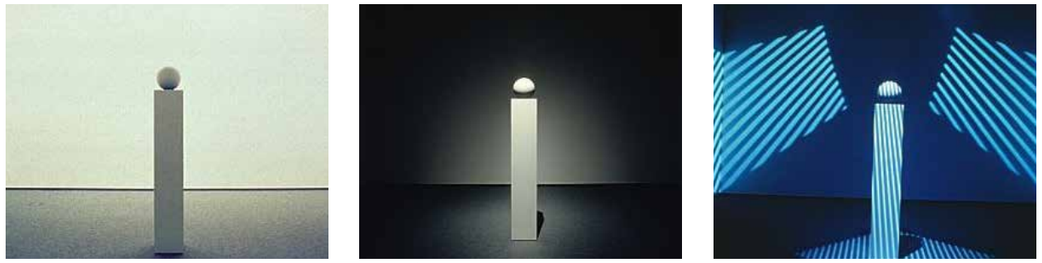


FIG.28 - Focal glow | Ambient luminescence | Play of brilliants

First and foremost is the "focal glow", understood as light to be seen, since illuminated areas attract the attention from others that are not. This could be extrapolated to the relationship between two bodies or objects that have different degrees of interest within the same space, such as a main door and a secondary door.

The second effect that Kelly studies is the "luminescent environment", which would be the light to see, understood as that elemental light to understand the space that is constant in the place as an element. In the words of Kelly, "ambient luminescence is the uninterrupted light of a snowy morning in the open country. It is foglight at sea in a small boat, it is twilight haze where a wide river where shore and water and sky are indistinguishable".

Lastly, we find the light to contemplate or Play of brilliants, which would be the scenic light, the one that is there to make that place unique and that brings a quality by itself, without needing anything else, as if it were a scenic focus. It is a big show, where the protagonist is the light source itself, rather than creating effects with external elements.

With the integration of these three forms of light, an effect of play of light and shadow is achieved, where the combination of light at different intensities makes one stand out from the other and where the sum of all is enough to develop our activities as human beings. No matter how much quality light is given in these spaces, the lighting has to be designed for the purpose of the people who live in that space, making its atmosphere integrate with it as much as possible

FROM CONCEPT TO PROJECT: INTEGRATION

Light points in architecture are not always a good partner in a project. Architecture lives between an artistic world and a normative world, and the law usually ends up ruling against the enhancement of light in architecture. The technological possibilities available today offer a huge range of possibilities that are beyond the scope of this study, but we will discuss what this integration is like and how architects project light.

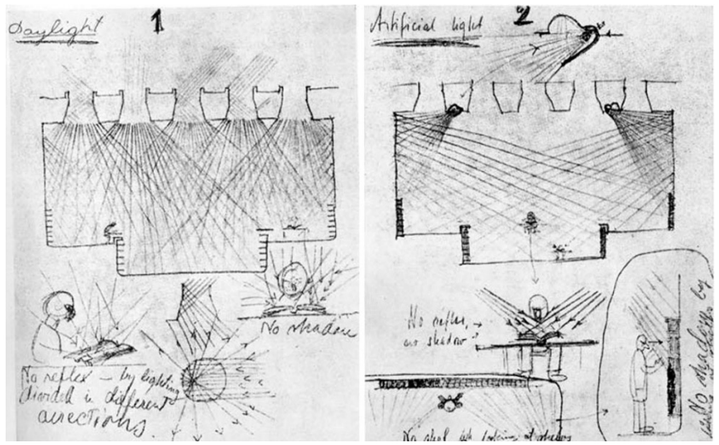


FIG.29 - Vyborg Library lighting diagrams and photos | Alvar Aalto

The integration of lighting elements into the project is not simply a matter of complying with the regulations of a certain number of m² lumens determined according to current legislation, but is a process of creation to show or hide what is of interest and what is not. Peter Zumthor says: "think of the building as a mass of shadows, then - as in an emptying process - make reservations for the installation that will allow the lights we want"[17]. Therefore, one of the problems that architecture generates from the artificial lighting of projects is how they are placed and what function they perform.

[17] Peter Zumthor. Atmósferas P.59

As the doctor in architecture Ramirez Valenzuela says in his article The use of lighting as a generator of theatricality in architecture, on the use of lighting as a generator of theatricality[18], he highlights two ways of designing lighting, where he differentiates the way in which architects design a light with respect to lighting designers in the theatre.

[18] Ramirez Valenzuela, Jhovana. El uso de la iluminación como generadora de teatralidad en l'arquitectura, may 25 2015, p.2.

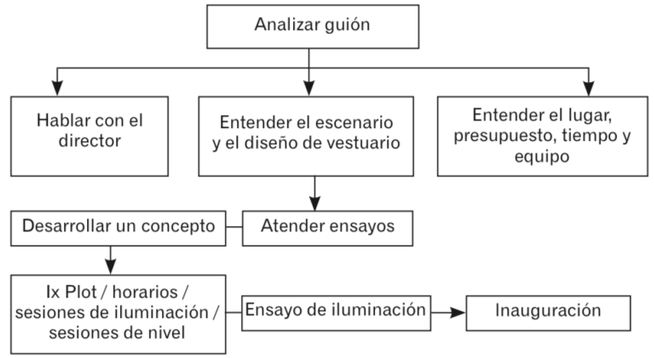


FIG.30 - Theatrical lighting design diagram

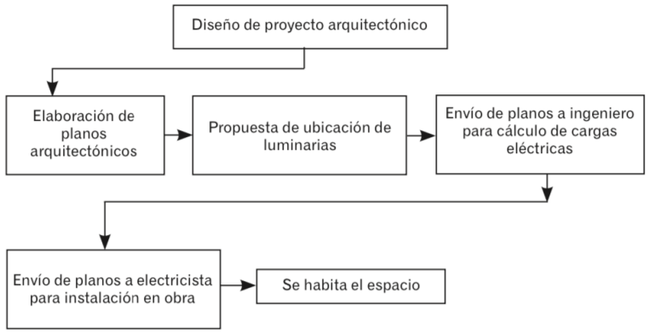


FIG.31 - Architectonic lighting design diagram

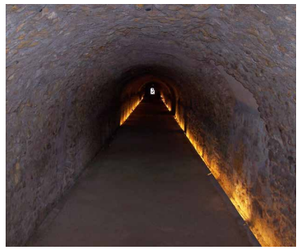


FIG.32 - Integration of lighting in a medieval tunnel

As it can be seen in the graphs, the methods used by stage lighting designers and architects are partly different, and this is where the problem arises. There is a difference: architects conceive the space very well, but not the light that will be artificially in that space. This, according to Ramirez himself, is because during the process of illuminating the space, neither the space nor the people who use it have been taken into account in a coordinated way.

That is why the architect has to be very conscious of the lighting they want to achieve in order to choose the right technology that will help them to achieve the desired result, so the plan should not show the luminaires, but rather the light that the luminaires produce. This will help to achieve a correct integration of light within the architecture, integrating a "role played with shadows". Shadows are a fundamental part of lightingz, since without them the desired effect would not be generated.

As mentioned in the previous sections on theatricality, atmosphere and integration, the three elements that determine which lighting should be taken into account are light, people and space. To achieve this, an atmosphere must be generated that is the sum of the elements of theatricality and where all of these are highly integrated.

CONCLUSION

CASA BATLLÓ FIXTURE LIGHTING. Barcelona | Carles Serrano 2017

CONCLUSION

Artificial lighting in architecture has progressed with the evolution of the technology available at any moment. The invention of electricity with the filament light bulb set a turning point in the way buildings were illuminated, and created a way of making art in architecture out of light.

One of the factors that most determines the way in which the lighting project of a building has been developed is the way it has been designed, whether quantitatively or qualitatively, since both aspects differ on whether architecture has to live from light. or light only has to be an exempt element of architecture in order to be able to establish a certain programme.

We cannot establish general guidelines for good lighting, as it is a concept that depends on the focus of the architect who designs it. There is no single rule on how to illuminate, but rather it is the architecture that sets the standards for how to illuminate it. Lighting can never overrule architecture, but without lighting the architecture loses its purpose, and the viewer must also be the centre of attention of the improvements it proposes.

The strategies presented in this project are the result of a research, which would certainly not have been carried out without my ten years of experience with stage lighting design, which allowed me to play, experiment and try as much as necessary to achieve lighting to transmit to the spectator the same sensations that I had imagined in a particular scene. With this intuitive knowledge, from the same experience, I have been able to continue contributing to the projects that have involved me, both personally and professionally.

The research and analysis of the works chosen for this work provide a broad and necessary vision to be able to establish premises to evaluate how artificial lighting has become involved in our lives and to establish parameters that manage to improve the lighting of the spaces in which we interact.

These strategies, which are the result of experimentation and study, may be valid to improve lighting in buildings, as this is the main objective of the project, as well as to establish a basis for improving lighting compliance in terms of quality and not so much quantity.

Lighting will progress and we will be able to find more and more advanced innovations that will allow us to adapt better to any type of architecture. But always bearing in mind that light has to complement our architecture to make it better, establishing *a* ***PLAY OF LIGHT AND SHADOW***.

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FIG.24 - Play with light, colors and textures
author of the project

FIG.25 - The light remark the arquitectonic elements
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FIG.29 - Vyborg Library lighting diagrams and photos | Alvar Aalto
https://www.metalocus.es/es/noticias/la-historia-de-la-biblioteca-de-alvar-aalto-en-vyborg

FIG.30 - Theatrical lighting design diagram
WILLIAMS, B. An Introduction to Stage Lighting

FIG.31 - Architectonic lighting design diagram
RAMIREZ, J. The use of lighting as a generator of theatricality in architecture

FIG.32 - Integration of lighting in a medieval tunnel
author of the project

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