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The Concept of Lighting Design by Creating Spatial Atmosphere for Human Health

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Abstract**—** *Light can be designed to give meaning and atmosphere according to the concept and purpose of the building. Humans have an inseparable attachment to light. For human life, light makes a significant contribution and has a role that can be seen and felt in physiological and psychological aspects. Physiologically, light greatly affects the performance of buildings that can be felt by humans through the sense of sight. Psychologically, light in space can create human perception that can improve human health. This is presented through color and material as a medium for the formation of light in space. Therefore, there is a need for spatial planning that can take advantage of the quality of light that has meaning for space users. The need for this research is to determine the quality of lighting that can affect human psychological health to improve health through the quality of lamp design. To obtain this information, it is necessary to conduct a building analysis that focuses on light quality. That way, it can find an indoor lighting strategy that can be used as a reference by paying attention to the layout and user perceptions that have an impact on physiological and psychological systems*.

Keywords**—** *Lighting, physiological, psychological, spatial design*

I. INTRODUCTION

Light can be designed to give meaning and atmosphere according to the concept and purpose of the building. When humans understand light can create various kinds of meaning, one of which as a natural resource. Through light, humans can see, feel, and create a different perception. The need for lighting in everyday life is unavoidable because the light is the main thing in human life and vision (1).

In human life, light can affect sensation and perception (2). The sensation caused by light can be felt by the human senses such as seeing visually. The resulting sensation effect affects the physical comfort of humans who are in space. The perception presented by light affects the psychology of humans who experience the atmosphere of space (2).

When viewed from architectural design, light has a role in addition to fulfilling building lighting (physiology) according to the activities of space, it can also form an atmosphere and atmosphere that can have meaning. When light is seen as an asset, light has a lot of exploration which is also related to color, elements, reflections, and textures to form the atmosphere of space (3). Of course, this spatial exploration collaboration presents a user's physical and psychological well-being. It's better looking at the lighting during the day, light has a blue light element. It can affect the body's health and circadian rhythm (4).

The use of lighting is certainly different in each building according to its designation. Lighting in a library with a museum must have a difference in the intensity and form of the resulting atmosphere. Al-Rhodesly (2019) revealed in his research that light naturally has a positive effect on the body and can also affect the atmosphere in a space (5). In addition, light has a perfect role and contribution to improving physical fitness, physical and psychological health also human productivity. This is because the light is a natural element that has a positive correlation with humans and their health (6).

This paper aims to describe the role of lighting in architectural design for both the physical and psychological health of its users. lighting is not only related to the level of lighting intensity but also can be seen in terms of the quality produced in a space that is in accordance with the objectives and needs of the space. The lighting in this paper covers the quality of light needed by buildings to improve the quality of space that can affect human health. So, in this paper, it is important to understand the human need to see light not only as a visual goal but also to feel the quality of light that is there for health.

II. METHODS

This research is a discussion based on a literature study and precedent. The aim is to explore criteria, concepts, and principles related to light to improve spatial quality. This research uses two stages, namely literature study and presentation. Literature study is used to search for theories related to design requirements (7). Theories related to this research are related to the design of light in architecture which is related and has an influence on spatial quality. Moreover, seeing how light is very important in the formation of space according to the Biophilic approach. Therefore, to strengthen the application of the theory, a precedent study was conducted. Precedent studies to obtain additional information related to the idea or concept of lighting and its strategies on buildings that have been built and buildings that have been researched (8).

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This precedent study uses an analysis of the application of light for purposes, priorities, framing, and the methods used in the building (9). The goal of this study is to apply light according to the purpose of the building. The method used can be in the form of methods when designing such as analogies, or those used during the thinking process at the beginning of the design such as the first principle thinking pattern. The first principle is a mechanism of thinking tools used to approach innovation and becomes one of the basic concepts (9).

III. Result and Discussion

This section describes the results and discusses the concept of playing light on each precedent building. Several things were found beside the idea, namely the use of materials and implementation of architectural elements as the execution of the concept of light in buildings.

A. Light Design in Architecture

Light can be divided into two, namely natural light and artificial light. Natural light can also be said to be daytime, namely, light that comes from the morning sun until the afternoon (1,4). This light has various benefits, apart from being the main lighting source, it can also support body health. Artificial lighting is commonly referred to as artificial light, namely artificial light that functions as a support for natural lighting.

Fig. 2. Guangzhou Opera House with Use of artificial light
(Virgile Simon Bertrand, 2018)

Artificial and natural lighting have different qualities. Most artificial lighting strategies play a role in supporting the atmosphere in the room (10). This is obtained by playing with lighting through brightness, color, and material levels as shown in figure 1 (2). These four things are the main considerations when playing light through artificial lighting.

Natural lighting is light that comes from the sun that enters or is reflected into the building (11). The color possessed by natural lighting follows the light entering the building as shown in Figure 2. Natural lighting has several aspects and principles that are different from artificial lighting. The natural lighting strategy is mostly by playing with the shape and pattern of openings in the building (2). The size of the opening and the orientation of the opening greatly affect the lighting conditions present in the room.

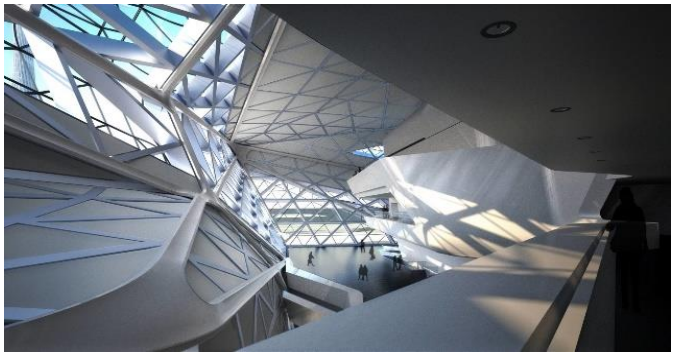

Fig. 1. The reflection of natural light at the Guangzhou opera house
(ZHA, 2010)

Light has both positive and negative sides to the health of the body during the morning and sick days. Natural or artificial, light always has radiation rays that can be identified as UVA, UVB, and UVC rays. Ultra Violet A (UVA) radiation is long-wave radiation, Ultra Violet B (UVB) radiation is short-wave radiation and Ultra Violet C (UVC) radiation is very short-wave radiation. Based on the journal Health, UVC is the most dangerous radiation but has been blocked by the ozone layer (12). In WHO research it is said that exposure to UVA rays can cause cancer. On the other hand, UVB rays produce a lot of vitamin D, which is good for the body. However, if exposed to this light for too long, the skin can darken and damage the skin melanin. Therefore, there are good hours to be exposed to the sun, from 07.00-11.00 and 15.00-17.00 without direct exposure to the body (13).

In case, viewed from the light principle in biophilic design, there are lighting characteristics. Physiologically, light has dark and light fluctuations. This is one way to be able to adapt and blend with an environment. Providing technology and construction as a physiological effect can also have a physiological effect on the user. Manipulation of the quality of light is achieved by playing with intensity, diffusion of light and shadow sources, and creative play of light (14).

B. Elements of Natural Lighting in Architecture

Perceptually, one way to explore the architecturally unnatural is to understand the nature of a biophilic design theory. Biophilic design is an effort that aims to translate the existing human interests combined with natural systems and processes (14). Understanding lighting using this approach is to understand light as an asset from nature as a medium to increase architectural value in space. Through this approach, more and more lighting can be found that is both quality and quantity,

The Biophilic Design has 6 elements and 14 patterns, one of which is the element of light and space. Light and space elements are natural and artificial lighting arrangements that can affect the condition and quality of space by playing with textures and surfaces. The elements of light and space have several aspects, namely:

1. Light naturally,
2. Dynamic and light scattering,

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3. Light & shadow,
4. Reflection pool of light,
5. Warm light,
6. Light is like shape and form
7. Spaciousness,
8. Spatial variability,
9. Space as form and form,
10. The harmony of space and space inside and outside

Determining the dimensions, elements, and aspects of the biophilic architecture in this design are determined based on the needs of the user's comfort in the building. The selection of the dimensions of light and space is based on the manifest of al-Rhodesly which states that light is very good for human health and productivity (5). The focus pattern is in the dynamic context and the spread of light. However, it should be underlined in this study that light is not only for health but also for forming the atmosphere of the space according to the derivative aspects of the light element and biophilic architectural space.

Natural lighting has a role in humans and the environment. In humans, natural lighting has a very positive effect on health and also creates comfort for humans (1). According to Boubekri (2008) that there are two ways of lighting that affect physiologically in humans, namely through the retina and interactions on the skin. lighting through the retina that affects metabolism and endocrine glands and hormones (15). Lighting that interacts with the skin brings photosynthesis to the skin which can produce vitamin D so it is good for human skin health. Therefore, the visual senses are fine in the absence of visual information, then filtered and brought to the brain in the parts of the hypothalamus which are responsible for the body's metabolic processes as energy and body fluid balance.

Fig. 3. Light as an affirmation of the geometric shape of the building (Kania, 2018)

Natural lighting can be felt in the exterior/environmental area as well as the interior which can present a psychological perception to humans. Externally, natural light plays a role in emphasizing the shape and geometry of the building (Figure 3). In the interior, light not only acts as a space affirmation but can also create an interaction between indoor and outdoor spaces and also brings visual comfort to the user (Figure 4). Visual comfort is a visual perception of space due to the presence of a light that illuminates space objects. Steffy (2002) in the book natural lighting in architecture reveals that there are five effects of lighting on humans, namely (1):

1. Visual Clarity, which refers to the user's ability to identify more deeply related to architectural and interior details, equipment, and objects.
2. Extensiveness refers to the user's perception of the volume in space
3. Preference is an overall evaluation of the lighting in the room
4. Relaxation is related to the intensity of lighting that is adjusted to the needs and needs of the room
5. Intimacy is related to the scale of privacy or intimacy presented in the room.

This is following what was stated by Louis Khan that physiologically, space is no longer a space when there is no natural light (16). Natural illumination can provide information regarding the time of day as well as the differences in the seasons. Thus, the light of nature and humans have a mutual attachment and cannot be separated from each other. The goal is not only for visual needs but because of the natural lighting that can provide a different atmosphere and atmosphere. These differences have very different effects on human comfort, physiologically and psychologically.

C. Application of Light for Psychological Comfort

In the analysis to determine the application of light design for user comfort psychologically, this is in accordance with a biophilic approach that focuses on light and space elements. The stages used in this analysis are knowing the goals, priorities, framing the theory, and the methods used.

Lighting can be a form of space through the interpretation of an understanding of a place or a space atmosphere (10). There is a game in this lighting that can give a different atmosphere to each room. In biophilic architecture, there are several aspects of playing natural and artificial light that resemble natural lighting in space:

a) Dynamic and diffuse

Figure 4 shows the existence of a lighting modulation game that aims to reduce the level of glare from the sun that enters the building. The advantage is that it can provide stimulation to the visual sense and is connected to the dimensions between spaces. The playing surface of the building provides appropriate shadows with appropriate textures. This can give the atmosphere of space and perception that is presented by every user who feels the space.

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Fig. 4. Dark and light game fluctuations in space
(Kania, 2018)

b) Light as visual perception

In Figure 4, there is a contrasting view of dark and complementary contrasts that can produce satisfaction both architecturally and landscaped. In addition, these lights and shadows can improve human movement and visual sense from near and far. This visual perception can also be called the affirmation of the existing building geometry in the presence of light.

c) Reflected light

In this aspect, light reflection is often found through light-colored walls, ceilings, and light reflective objects. In Figure 5, you can see reflected light which has the benefit of creating a silhouette of light, providing dark and light transparency, while providing dynamics and creating a transparency effect (4).

Fig. 5. Light reflection game effect
(Color, 2018)

d) Light pools

In Figure 6, there is a collection of lights that are connected through the space, thereby increasing the user's interest to follow and feel it. In the image it appears that a collection of light becomes direct in motion, finding its way through the presence of ordinary light throughout the enclosed area. One of the benefits that can be felt by having light pools is a sense of security and protection.

Fig. 6. Light rain as an expression of space quality
(Time, 2021)

e) Warm light

The light that seems warm in its application is in the form of light that resembles the modulation of sunlight. As can be seen in figure 7, the surroundings are often dark, so the presence of warm light can foster a sense of place in an attractive and safe interior. The use of warm color lighting can be used by using natural lighting as shown in figure 8 and artificial figure 7. This also affects the perceived condition of the place by using different materials, shapes, and colors.

Fig. 7. Room using warm color lighting type with artificial lighting
(Lane, 2022)

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Fig. 8. Room with warm colors using sunlight
(Premises, 2021)

f) Spaciousness

The relationship between the space that shows feelings of pleasure with the natural and artificial environment is shown in Figure 9. There is a complementary relationship with the shelter and shelter in it and even around it.

Fig. 9. Between natural and artificial
(Mathew Segal, 2021)

g) Harmonization of space

Manipulation of space in the built environment by effectively combining light, mass, and scale in the limited context is shown in figure 10. The goal is to generate a sense of unity/harmonization that can foster a sense of security, and always facilitate every movement in its various elements.

a. Indoor and outdoor space (In-Between)

The relationship between the interior space and the outside environment that can create an interesting and fresh feeling is shown in Figure 11. This area also has natural music with the surrounding culture. Design forms that are important in the built environment can evoke quality, such as pillars, verandas, porches, atriums, and interior gardens.

Fig. 10. A balanced composition creates a harmony in space
(Ruetemple, 2016)

Fig. 11. Transparent relationship of interior space with outdoor space
(Lewin Nuramin, 2021)

D. Lighting Design Studies Through Built-up Buildings

In this precedent study, there are several points that are discussed based on the needs in the design related to the play of light in the room that can affect the health and atmosphere in the room. The play of light associated with each building is related to the use of light and space in the context of dynamic and diffuse light. The buildings that were discussed in the lighting study strategy in this building were the Guangzhou

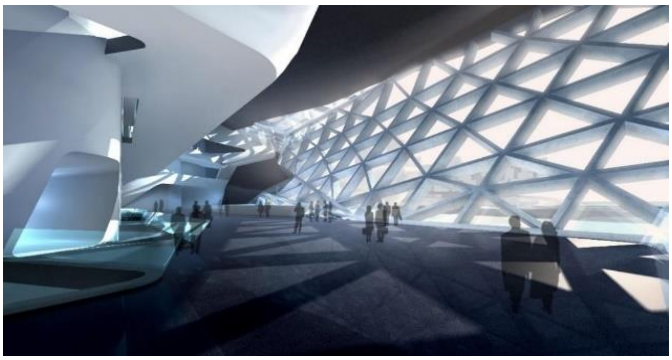

Fig. 12. Usually, the afternoon sun hits the geometric shape of the building envelope
(ZHA, 2010)

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Opera House by Zaha Hadid Architect, Reflection of Mineral by Atelier Tekuto, and the Louvre Abu Dhabi by Ateliers Hean Nouvel. The Zaha Hadid building is an Opera House with the theme of the building from natural wealth, one of which is the lighting under the building through the geometry of the building. Mineral Reflection is a residence located in a residential area with very minimal land. However, the land has good light potential. So, it is found a strategy of building form that follows the orientation of the movement of the sun's pattern in the area. Louvre Abu Dhabi is a museum building located on the sea coast. This building has the main building concept of light rain and creates the rain pattern through the roof of the building which is arranged to have 8 layers of roof.

a. Light as an implementation of the building concept

Light as an implementation of the building concept by providing light entry into the space by emphasizing the shape of the building and maintaining humans physically. The lighting effect on buildings that affect the impression of different users on space is the arrangement of space, atmosphere, and resulting visibility (2). Some examples of

Fig. 13. The concept of light like a star
(ZHA, 2018)

buildings that illustrate the first are the Guangzhou Opera House. This building has the concept of lighting as a tool for affirming the architectural form of the building. The Opera House building by Zaha Hadid has a geometric modification on the side of the opening/side of the building that is exposed to sunlight in figure 12. On the interior side of the hall, various light concepts are shown as an affirmation of the architectural form of the building. In figure 13, there is an aura emitting in the space which is shown in gold and shiny colors. The existence of an expressive formation and utilizing the potential of light to emphasize the shape so that the building looks sturdy and has ordinary light that matches the shape of the existing opening.

The building which has the nickname "The Double Pebble" is the result of a parametric architectural concept from Zaha Hadid Architects in the form of an analogy of two pebbles eroded by erosion (17). The concept of Guangzhou design is the evolution of the concept of nature through an interesting interaction between architecture and nature. Based on the Archdaily page in 2011 it was stated that this building carried the principles of erosion, geology, and topography and was strongly influenced by river valleys and the way the river valleys changed. This building takes a concept taken from fluidity and nature, this is the design strength of Zaha Hadid which is very thick and can be felt in several aspects of the

Fig. 14. Exterior surface Guangzhou Opera House
(Giovannini, 2011)

building (17). Shown from the exterior, interior, acoustic elements, and executed with the play of light given to the sides of the elements in the building.

b. Light as asset and constraint

The building that will be the next study is the Reflection of Mineral Building. This building focuses on the integration between natural light and humans. Reflection Mineral has the concept of entering light directly into the building. The purpose of the inclusion of natural light is to transparency the relationship between nature and the human who are in the design. There is a driving force in the design, namely light as a force to form a shape as shown in Figure 15. To make the design visible, this building uses an architectural composition that is adapted to design elements that interact with the environment, space, and needs that affect spatial quality. This is also emphasized by considering the condition of architectural elements according to constraints and assets such as geometry, architectural elements, textures, shapes, and surface colors.

This material reflection building design uses the criteria selection method presented in the architectural diagram by describing the composition of the building based on assets and light limitations on the site. The tools used are sectional by describing the formal response in the form of section space. Furthermore, using programmatic by presenting the layout of the building in accordance with the space program and its designation as seen in picture 15.

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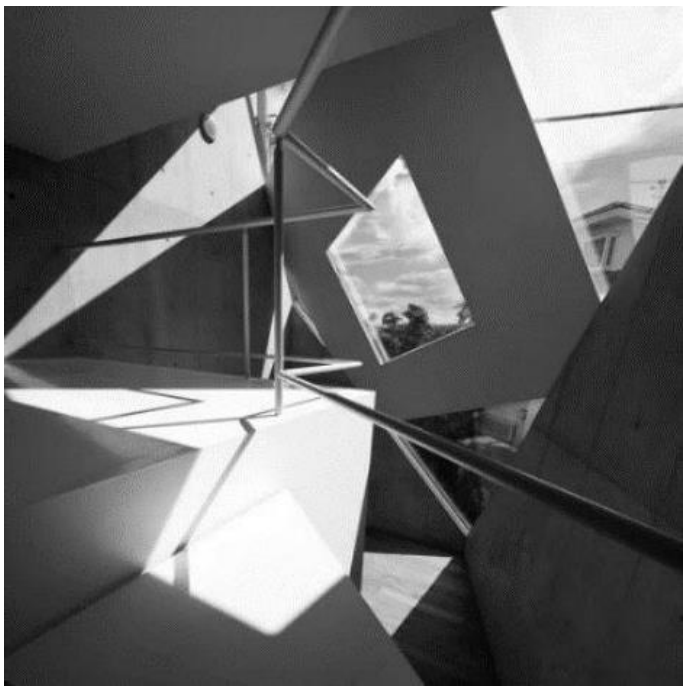


Fig. 15. Interior House of Mineral
(Plowright, 2014)

Starting from the site by looking at the direction of the visible light source according to its assets and limitations, then making a spatial design according to the initial analysis and positioning the spaces according to the function needs.

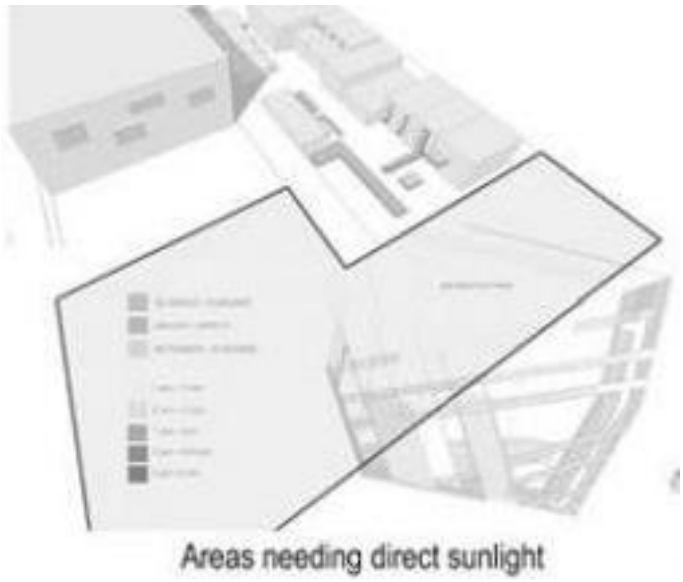
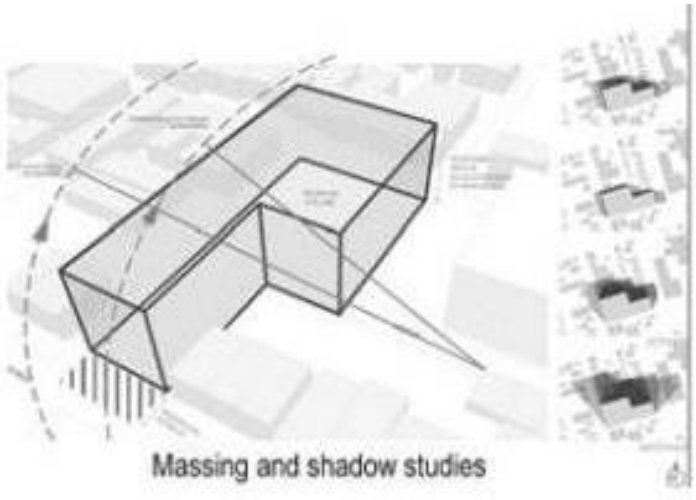


Fig. 16. Site analysis with direct sunlight
(Plowright, 2014)



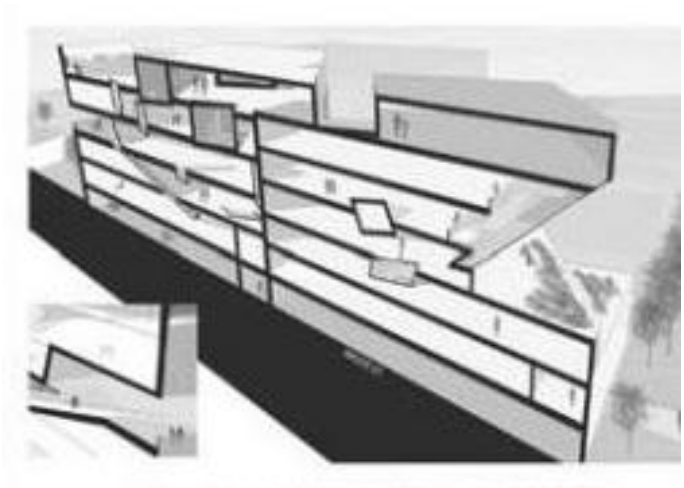


Fig. 17. Architectural details on the design House of Mineral
(Plowright, 2014)

c. Light as the Main Power in the Concept of Building Design

Lighting considerations are not only for emphasizing architectural elements and the specificity of the entry of light into the space. Lighting games can also be played through building envelope games that are shaped in such a way that it produces a new design technique that enters the building. The third is the Louvre Abu Dhabi which is in the country of Abu Dhabi. The Louvre is a museum building with the concept of light using parametric principles of light-based design (Tourre & Miguet, 2009). Through this principle, there is a touch of biophilic architecture in the light concept, namely by focusing on the light pools and paying attention to the surrounding conditions as shown in Figure 18. This has the aim of achieving the main concept, namely "Rain of Light" which can affect the atmosphere of visitors to events. that happens in space. This is shown through a light that can fall on buildings like a raindrop falling on the earth.

From an overall structural point of view, the building uses a pair of asymmetrical structures with the dome and curtain walls joined together as shown in figure 19. The gigantic steel lattice that forms the dome with the exterior structure extends in all directions from the inner concrete volume. . It forms a

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shell with triangular flat sides with steel members (Giovannini, 2011). The flat side is a steel plate that is folded in 3 inclined directions with the aim of forming the surfaces and angles of the structural facade. There are two focal buildings using different structures, this was smoothed out by

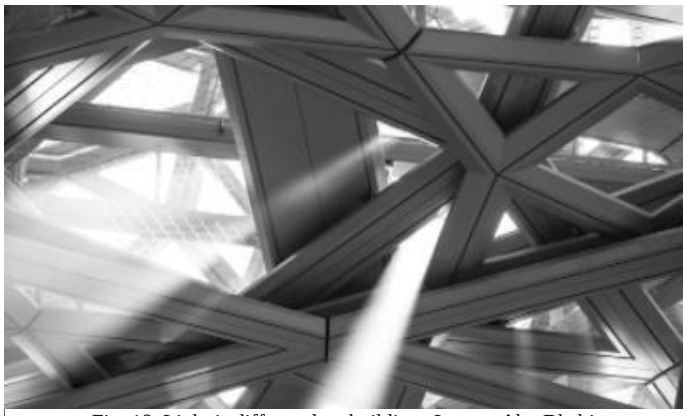

Fig. 18. Light is diffracted on buildings Louvre Abu Dhabi
(Moly, 2019)

covering them with triangular tiles of rough granite.

Figure 21 shows the structure used in this building. It has 8 layers of roof, each layer is rotated, and there is a play of scale and random perception of logical geometric patterns (Abourezk, 2017). These layers are supported by four towers that are between various spatial structures with irregular spacing as shown in figure 20. The top 4 layers are made of stainless duplex steel because it is the layer that changes the most climate changes, and is the most susceptible to climate change (Moly, 2019).

The first sheet/layer is welded and loaded with extruded aluminum substructure through neoprene insulation joints to avoid galvanic corrosion of aluminum by stainless steel. The use of this construction is to make it easier in terms of manufacture, implementation, durability, and also its ability to reflect light. The poles used as supports use a leak-proof concrete structure drilled up to 15m below sea level to support the entire building (Moly, 2019).

Through the concept of playing light in the building by presenting different concepts according to the designation of space. It takes a technical strategy as the implementation of the play of light on architectural elements. As has been stated in Marisha McAuliffe's book that the play of light also occurs because of the general perception that is presented (Tourre & Miguet, 2009):

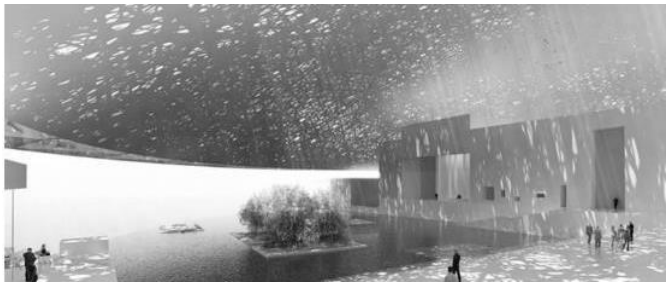

Fig. 19. Light pools in buildings Louvre Abu Dhabi
(Toure & Miguet, 2019)

a. Space
b. Form
c. Facade
d. Texture
e. color
f. Light

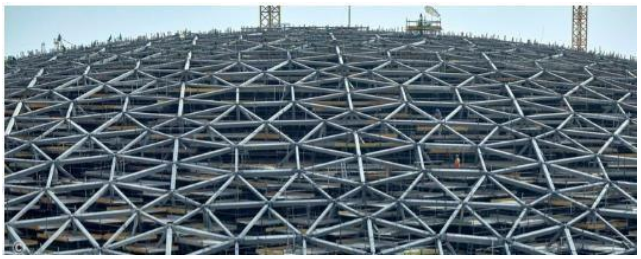

Fig. 20. Roof structure of Louvre
(Moly, 2019)

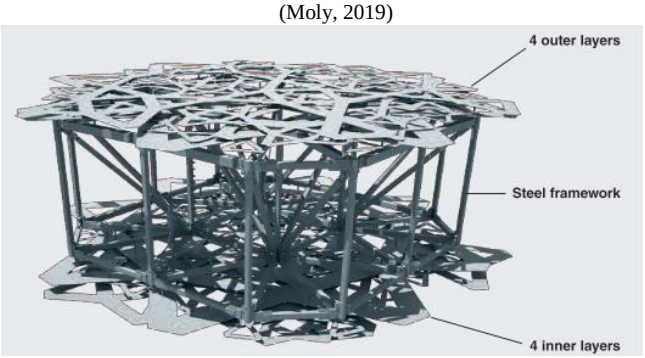

Fig. 21. Louvre roof pattern
(Abourezk, 2017)

E. Formulation of Criteria and Concepts of Light in Architectural Design

Based on theoretical studies and precedents that have been carried out, it was found that the actual presence of light can contribute to health. Especially physiologically and psychologically for building users. As for the things that must be considered in the design to provide a quality spatial layout according to needs, namely:

- Seeing the lighting conditions in the environment around the design location to be able to determine the best design orientation
- Determine the lighting position according to the needs of the exposed space or elements to get a bold shape
- Taking into account the dimensions of the aperture given in the main orientation of the design
- Selection of materials that can reduce heat in buildings and the effects of heat generated

The building study that has been submitted previously is one way to translate lighting in a building. The concept of improving physiological and psychological health caused by natural lighting in particular must pay attention to the level of building openings in the space. this is influenced by the time of natural lighting which is good for the body only in the morning and before noon. Through this consideration, position, orientation, shape, color, and texture are very much considered in supporting the design concept.

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IV. CONCLUTION

Based on the analysis that has been done in this paper, it was found that light is not only about how bright and dark it is for lighting a room but can be seen in terms of the quality of light which can give a different atmosphere to an architectural design. This of course has a relationship with user needs. In addition, lighting can also emphasize the expression of the building so that the strength of the geometric shape of the building can be seen and create interesting architectural values. Natural and artificial lighting has a relationship with the quality of space through the colors, textures, and materials provided.

The results of this study will be continued to determine the criteria for designing a gym building that pays attention to light which can affect the quality of space when exercising. The need for quality space, among others, is to support a space atmosphere that can improve the health of users. This research is an initial study to determine the best design proposal for gym light design. These results can be applied to buildings in general that have a focus on the quality of light design, but the results of this study are basically part of design research to find supporting theories, criteria, principles, and concepts for gym design.

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