

Research on the Application Strategy of Light Healing Design in Desert Area Architecture

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Abstract. This research studies the application of light healing design in desert area architecture. Drawing on the desert's unique advantages, including ample daylight, diverse dune forms, a range of landscapes, and distinctive vegetation, and taking into account the lighting requirements of the population in the desert, research proposes two light healing design methods for the desert area: daylighting and artificial lighting. Through literature review and case analysis, the design strategy of desert light healing was formed. The aim is to provide inspiration for the location of desert architecture and the design of light healing technology and improve the physical and mental health and emotional regulation of people in desert areas.

Keywords: Light healing; desert; daylighting; artificial lighting.

1. Introduction

Human health is closely related to architectural space. One of the important factors affecting human happiness and health in architectural space is light, which plays an indispensable role in the healthy development of human beings. Because light has a great healing influence and regulatory effect on the human body. Light can impact human health via the visual and non-visual systems originating in the retina of the eye or as optical radiation falling on eye or skin [1]. In the healing that light brings, light curing and light healing are two different concepts [2]. Light Curing pays more attention to the disease itself, eliminates the disease through light treatment, and allows the state of illness or injury to recover as soon as possible [2]. Light Healing is the concept mentioned in this paper, which is in line with the active health concept advocated by modern medicine [2]. It focuses on the underlying causes of diseases and unhealthy states based on people's demands, enhances the human body's ability to adjust and adapt, and improves health levels by applying controllable stimulation. Healing cannot replace professional light therapy to cure diseases [2]. However, it can provide help for the pain that medical treatment cannot do, so that physical and mental discomfort can be relieved [2].

In the past 30 years, global research on light and human habitat health has become more and more popular year by year, and the impact of light on human health has received more and more attention. A large number of scholars have brought more research possibilities and broad research prospects for light healing through interdisciplinary research. A large number of studies have shown that light healing can have a positive impact on people's physiology, psychology, cognition, and behavior. First of all, light healing will have a positive impact on physiology, such as avoiding environmental pathogenic factors, promoting the rehabilitation process, regulating sleep difficulties, emotional disorders, chronic fatigue, neurological disorders, and other physical stress problems, and promoting the process of human recovery and the benign transformation of health states [2]. Secondly, light healing will also positively affect people on a psychological level, such as happiness, a sense of achievement, a sense of security, better perception of the environment for human beings, and play a healing role in regulating emotions and neurological functions [3]. In addition, light healing has positive cognitive and behavioral effects on different populations. Light healing can improve learning efficiency and attention in educational places, and create a healthy and comfortable learning environment. It promotes family harmony and creates a warm atmosphere in private places; in the business place, it helps to relieve work pressure and improve work efficiency and comfort [2].

The world's desert area accounts for 35% of the land surface area, 45.608 million square kilometers, there are many desert areas and desert landscape types among various countries. At the same time, due to natural phenomena and human interference, more and more areas in the world are facing desertification [4]. The desert environment is often accompanied by a hot and dry climate, monotonous environment and landscape. It can negatively impact human emotion, and make people susceptible to psychological interference [5]. Therefore, it is urgent and important to help large numbers of people in vast desert areas quickly and effectively recover their physical functions and mental and emotional regulation. The desert has its unique environmental conditions, and the light healing design can be combined with the particularity of the desert environment to explore the light healing lighting strategy suitable for the use of buildings in desert areas, to bring visual health, mood, sleep, cognition, work efficiency and other aspects of improvement for people in desert areas [2]. Through the light healing design of buildings in desert areas, people, environment, and health are closely integrated to improve the quality of life and bring health and well-being to people in desert areas [2].

The research topic of this paper is the application of light healing design in desert area architecture. Through literature review and case analysis, this paper studies the advantages of combining the desert environment with light healing design, which main advantage is ample daylight conditions. At the same time, the desert has diverse dune forms, coexistence of various landscapes, and distinctive vegetation; these three points constitute other advantages of desert light healing design. After conducting a thorough analysis of the needs of individuals residing in the desert region, research proceeds to examine the specific lighting requirements necessary for various activities within the space. Subsequently, research endeavors to establish an effective application strategy for light healing design in desert environments, and two light healing lighting design methods in the desert area are obtained, including the daylighting method and artificial light lighting method.

The research methods employed in this paper involve consulting books, compiling literature, and gathering network information. This approach allows the research to analyze and summarize the current status of light healing, explore design techniques, and identify the unique characteristics of desert regions. By doing so, research establishes a solid foundation for further investigating light healing and selecting appropriate sites for desert architecture. At the same time, research collects international design cases, and obtains the design method of desert light healing by analyzing the desert architecture, traditional healing space, and light healing cases, which inspired subsequent research strategies.

This research hopes to further improve the physical and mental health of people in desert areas and get positive emotional regulation by using good light healing design strategies of architectural space in desert areas.

2. Advantages of Light Healing in Desert Areas

2.1. The Main Advantage of Desert

The lighting level in desert regions is ample, primarily attributed to a range of factors including latitude, altitude, vegetation, and climate [6]. Specifically, for desert areas located at lower latitudes, they experience a greater solar altitude compared to those at higher latitudes, resulting in increased solar radiation. Additionally, deserts situated at higher altitudes are closer to the sun, boosting the intensity of sunlight. Furthermore, deserts are vast landscapes with minimal vegetation coverage, so it will bring less vegetation shadow shelter to the indoors, thereby enhancing indoor lighting conditions. Moreover, due to the low precipitation and water vapor content in desert areas, there are relatively low clouds and relatively low columns of ozone, which will reduce solar shielding on the desert surface and strengthen solar radiation [6].

Desert areas have plenty of daylight, which provides a rich natural light source for the application of light healing techniques. The solar spectrum is continuous and gentle, and the color rendering is superior, so it is the healthiest and most comfortable lighting source for the human eye [2]. Moreover,

sunlight affects the secretion of three neurotransmitters, dopamine, serotonin, and endorphins, which regulate people's physical, mental, and emotional experiences, affecting mood, brain function, pain response, and cognitive abilities, as well as circadian rhythms, so sunlight is extremely important to the human body [2]. Through suitable design and utilization, desert buildings can make full use of sunlight to improve the indoor environment and improve the comfort and health of occupants.

Daylight can be utilized effectively through the design of form, space, and materials within a building, and then create an interactive environment that harmonizes the relationship between people and their environment [7]. Daylight in desert areas can be used in diverse forms, such as direct, diffuse, refraction, transmission, contrast of light and shade, manufacturing of light and shadow, and color transformation, so that the shape, space, details, and interface texture of buildings in the desert can be presented, and then create rich aesthetic effects for the space. This plays an important role in guiding people's emotions, improving people's happiness, and making people's lives healthier.

2.2. Other Advantages of Desert

There are diverse aesthetic desert forms in desert areas. As the sands and gravel shift constantly with the whim of the wind, the dunes take shape in unique lines, exuding a rich and organic beauty. With the gentle and convex terrain, as well as the huge volume and drop of tall sand mountains in some deserts, the combination of these dunes will make the desert area look unique [8]. For example, dunes can form the shape of high peaks, and sand ridges, and produce the effect of sand valleys. Each region of the desert has its own beauty and unique charm, lighting can be combined with the characteristics of the desert, such as the use of sand, extracting the shape of dunes, and other design techniques, to create a special light healing effect of the art design. Furthermore, the dunes' inherent sense of dynamism and flow can be enhanced through dynamic lighting techniques, creating a transformative visual experience that brings a sense of stability and healing to the observer.

Many kinds of landscapes coexist in desert areas. Sleek dunes, colorful lakes, mysterious Yadan landforms, shimmering salt deserts, strange wildlife, and even deserts meeting the sea - all coexist in these regions, displaying the rich and diverse natural beauty of the desert. A variety of natural landscapes can be combined with light healing design, and the ingenious use of light and color can bring physical and mental healing effects to tourists, trigger people's exploration of the unknown sense of desert mystery and mobilize their love and positive emotions for life and nature.

Desert areas have distinctive vegetation types. Ornamental vegetation landscape has emotional mediation and healing effects, and some studies have shown that vegetation combined with light and shadow can trigger people's positive emotions. In a series of studies on the association of environmental variables with children's mood and behavior, Nandineni Rame Devi and other researchers have found that patterns of light spots or shadows produced by artificial and natural light can trigger positive emotions [2]. Landscape plants combined with light and shadow techniques can bring vitality and energy to space. In the desert, many novel plants are not common in People's Daily lives, such as *Populus euphratica*, red willow, sea buckthorn, and cactus. By integrating these unique plants with light and shadow techniques, people can not only stimulate positive emotions but also ignite a desire to explore the environment and life, mobilizing one's curiosity.

3. Light Healing Design Strategy

3.1. Strategy

Studies have shown that in extremely arid desert environments, after seeing the monotony of the same type of environment and landscape for a long time, people's enjoyment of the conditions may be weakened, and they are susceptible to psychological interference [5]. The desert environment is often accompanied by a hot and dry climate, and such a living environment is easy to cause anxiety and psychological problems. People in desert areas need to avoid the negative effects of direct ultraviolet rays and strong sunshine on their bodies, but at the same time, sufficient and soft daylighting is needed to ensure the health of the body's function. Moreover, artificial light is needed

to supplement the lighting for the spaces that have inadequate natural lighting. In addition, for the desert's monotonous environment, it is necessary to refer to other external factors that are different from the desert environment to bring changes to the architectural space. In this way, spaces can stimulate people's emotions and regulate their psychological pressure.

The active intervention effect of lighting on the problem of population health is outstanding, and the application is convenient and flexible, which can be well integrated into people's daily lives and reduce people's physical and mental health burdens [2]. Light affects human health and performance in four main ways: it helps visual tasks work, regulates the body's circadian system, affects mood and perception, and makes it easier for the body to absorb chemical reactions that are vital to the body. Light has the most direct effect on humans in making it possible to see and perform visual tasks [7]. The viewer's visual capabilities, the characteristics of visual tasks, the lighting environment, and the workspace are the four factors that determine it [9]. Visual function, comfort, safety, and aesthetics are greatly affected by lighting parameters like illuminance, light source color temperature, color rendering, flickering, and glare. Lighting parameters should be strictly regulated [2].

In desert areas, it is necessary to give the space aesthetic characteristics and eliminate the adverse factors in the space environment through the customized design of illumination intensity, color, color temperature, direction, distribution, and other parameters and combinations as well as various art installations [2]. In desert areas and buildings, to prevent the high intensity of direct solar radiation and ultraviolet radiation from harming the human body, indoor spaces should maximize the use of suitable shading systems to control light components and introduce daylight. One of the important light healing design strategies in desert architecture is that daylighting design should be combined with artificial light lighting design. For instance, daylighting design should be used during the day, with artificial light supplementing and auxiliary lighting. In addition, intelligent control systems and adjusting building interface materials are used to effectively achieve balanced lighting control of daylight and artificial light in different periods. Moreover, in the design of light healing in desert areas, analyzing color psychology, using dynamic light application and appropriate light casting direction should be combined to achieve harmony and healing effect in architectural space and bring positive impact on the human body.

3.2. Design Methods

3.2.1. Methods of daylight design

First, the daylighting design of buildings in desert areas can use flexible light-control components. Glazing is a key part of the building's light-healing natural light design, as it controls solar radiation and light paths. Through special glazing design or light environment creation, unique light and shadow effects can be created for the interior, increasing the sense of layer and beauty of the space. Due to the special geographical location of the desert area, the traffic conditions are not convenient, so it is necessary to use prefabricated, modular construction of light control component design to reduce transportation and construction costs. At the same time, the light control component can cleverly adjust and control the indoor lighting. Specifically, the design of light control components can increase the amount of light in the deep by raising windows or adding reflectors, selecting heat reflective or low radiation glass to control insulation, designing bay windows to compensate for the lack of direct sunlight, and using parametric methods to obtain the appropriate amount of light intake in the room [2]. For example, Louis Isadore Kahn designed the Kimbell Art Museum, the architect designed a light control component, and applied it to the entire building, to form a clever control of natural light intake. Daylight enters through narrow plexiglass skylights along the top of the pendulum-shaped vault and is then diffused by a perforated aluminum reflector suspended below, which brings a silvery glow to the smooth concrete surface of the vault and provides perfect, subtle natural lighting for the artwork (attached Figure 1). In the desert area, if the use of this flexible assembly of light control components, can effectively avoid direct sunlight, and block the negative impact of ultraviolet radiation on the human body under strong sunlight. Also, it can bring good lighting conditions and artistic effects to the space. Moreover, it can avoid the inconvenience caused

by transport limitations in the region. On the other hand, desert environments are susceptible to wind, and dunes flow with the wind, forming different shapes at different times. Therefore, when designing light healing, it's imperative to assess the potential impact of dunes on indoor lighting, as they could potentially obstruct light, casting shadows and thereby compromising indoor illumination. To be specific, without altering the daylight spectrum, the design of light control components incorporates the principle of reflecting light using plane mirrors or prisms to redirect the direction and intensity of incident light, thereby optimizing indoor light distribution, and addressing issues of inadequate lighting.



Fig 1. The Kimbell Art Museum, Louis Isadore Kahn, Texas, United States. © Richard Anderson.

The second daylighting design method is to design the shading system. Because desert areas have plenty of daylight and strong solar radiation, buildings need to design shading systems to avoid direct and excessive sunlight entering the room, while preventing glare and blocking solar radiation to avoid overheating. Shading systems have a strong effect on the improvement of building performance and human comfort. For example, the shading system at Louis Isadore Kahn's Morton Weiss House is cleverly designed to allow residents to determine the amount of light that enters the room at different times of the day by controlling the transparent and opaque panels in the living space (attached Figure 2). Based on the level of solar radiation intensity in desert areas, designers should consider the priority of shading design and choose the appropriate form. Shading components should be considered synchronously and integrated with light healing design, and become a combination of function, art, and technology. In addition, the intelligent control system can be used to achieve the linkage effect of shading, lighting, and indoor lighting. For instance, the building uses intelligent control systems to automatically close or open blackout curtains and artificial lighting equipment to create high-quality indoor lighting that balances artificial light with daylight [2].

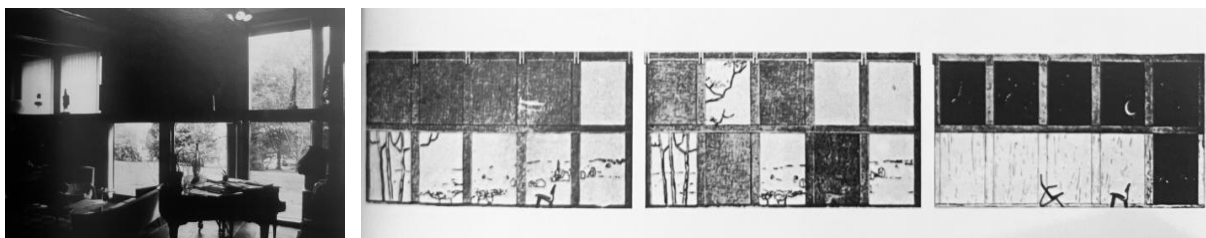


Fig 2. Morton Weiss House, Louis Isadore Kahn, Pennsylvania, United States. © Louis I. Kahn: Light and Space, Urs Büttiker.

A third approach to daylighting design is to increase the movement of light. A large number of studies have shown that dynamic lighting will have a beneficial impact on the human body, such as allowing individuals to maintain a stable psychological state and operational skills for a long period of time [10], reducing physical activity and aggressive behavior [2], relieving patients' anxiety and promoting the recovery of stable emotions [2]. In the desert area, the sand can move with the wind, and the dynamic sense of mobility of the desert can be combined with the dynamic light to form a unique visual stimulation and transformation effect so that people can get a stable mood healing experience. At the same time, it can be considered to combine the running track of sunlight in different

times and seasons in desert areas and the change of the sun's height Angle, combining the light healing design with the changing light to bring different interior beauty and significance to different spaces in the building.

Moreover, the architect can also consider the installation of light wells. Light wells in desert areas, often accompanied by the introduction of light and heat transfer, are also important aesthetic methods and ventilation strategies. For example, in the UCCA Dunes art museum, designed by OPEN, the skylights of different sizes and different orientations are designed to combine the characteristics of the dune terrain, so that daylight from the high dome is introduced into the interior, becoming the main way of lighting during the day, making people feel quiet and refreshing (attached Figure 3). In desert areas, daylighting wells can be used from different angles and combined with dune topography to introduce daylighting. Meanwhile, the top material of daylighting Wells needs to consider the special environment of desert areas and has the function of sand prevention, convenience of on-site assembly, and filtering strong light.



Fig 3. UCCA Dunes Art Museum, OPEN Architectural Office, Hebei, China. © Wu qingshan.

In addition, the design of daylighting in desert areas needs to consider building materials. In desert areas, the application of materials is an essential means to improve the quality of indoor daylight and optimize the distribution of light [2]. For example, the BEEAH headquarters in the Al Saja desert in Sharjah, United Arab Emirates, designed by Zaha Hadid Architects, uses fiberglass reinforced panels to reduce the impact of solar radiation, and at the same time, the fiberglass reinforced panels have better light transmission, creating a unique light and shadow experience for the interior (attached Figure 4). In the case of desert architecture, the design makes full use of the characteristics of different exterior materials, divides the design of these materials, and mixes a variety of materials, such as the combination of different transmittance materials, so that the light can get a variety of aesthetic effects in the room.

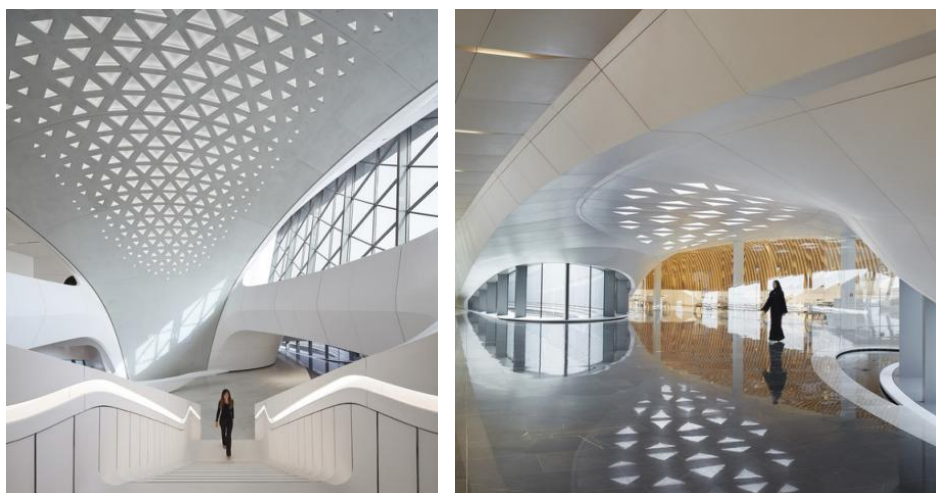


Fig 4. BEEAH Headquarters building, Zaha Hadid Architects, Sharjah, United Arab Emirates. © Hufton+Crow.

Last but not least, changing the daylight color is also an important daylighting design method for buildings in desert areas. Light and color are very effective means of healing, their healing effect lies in the three aspects - visual, physiological, and psychological, as positive stimulus elements, their accumulation can help people recover, and maintain a healthy and stable physical and mental state [2]. By changing the color of daylight, the interior can be presented with colorful light and shadow to achieve a special atmosphere. For example, the meditation chapel designed by Lee Eunseok and ATELIER KOMA in South Korea uses 12 funnel-shaped stained-glass Windows for the building's concrete facade, filling the interior and exterior with green, a metaphor for nature. Indoor people can constantly perceive nature by watching the position of colored light and the change of light and dark and achieve a stable and peaceful state of mind in a closed space (attached Figure 5). In the desert, the sand in the same area, due to its rich mineral composition and environmental conditions, forms different colors, usually appearing yellow, red, white, gray, pink, or black colors. Because the human eye looks at the same monotonous color for a long time, it will cause visual fatigue and emotional fluctuations, so it is particularly important to introduce other colors that have a positive impact on vision in the desert architectural space. For instance, the green stained glass presented in this case can help people in desert areas to relieve visual fatigue, perceive environmental changes and natural vitality, regulate psychological conditions, and stabilize emotions. Furthermore, in the design of light healing in desert areas, you can also use the special color of the desert combined with light color to form a unique healing experience.

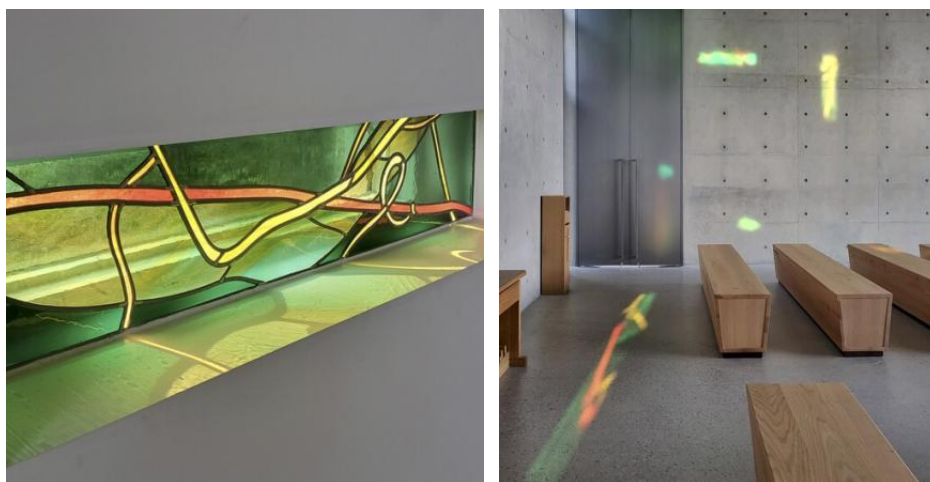


Fig 5. Meditation chapel, Lee Eunseok & ATELIER KOMA, Korea. © Urban Azit.

3.2.2. Methods of artificial light design

First and foremost, the artificial light lighting design of buildings in desert areas needs to improve the artificial light color temperature. In summer, the desert region has a unique climate, with a significant morning and evening temperature difference. During the day, the desert area is relatively hot, and the human body easily feels uncomfortable. At the same time, the sand in the daytime shows a monotonous golden effect under the irradiation of the sun, which will give people a dull feeling. According to research, in hot desert areas, people tend to prefer cool light, and the use of high-color temperature cold light can give people a feeling of calm and comfort [11]. At night, the sand doesn't have the same bright yellow color as it does during the day, while the night temperature is low, so at night, the space can use warm lights to give people a warm feeling. For example, in the cholera treatment center in Haiti designed by MASS Design Group, the building mainly uses large skylights and light control components on the facade to ensure the indoor sunlight supply during the day, presenting a comfortable and cool space effect, and providing sufficient light conditions for indoor disinfection, doctor treatment, and patient rehabilitation. At night, the building mainly uses warm white artificial lighting, which is different from the cold light in the general hospital. The warm and comfortable warm light brings the feeling of warmth and healing to the patients and promotes the mental health of the patients (attached Figure 6).

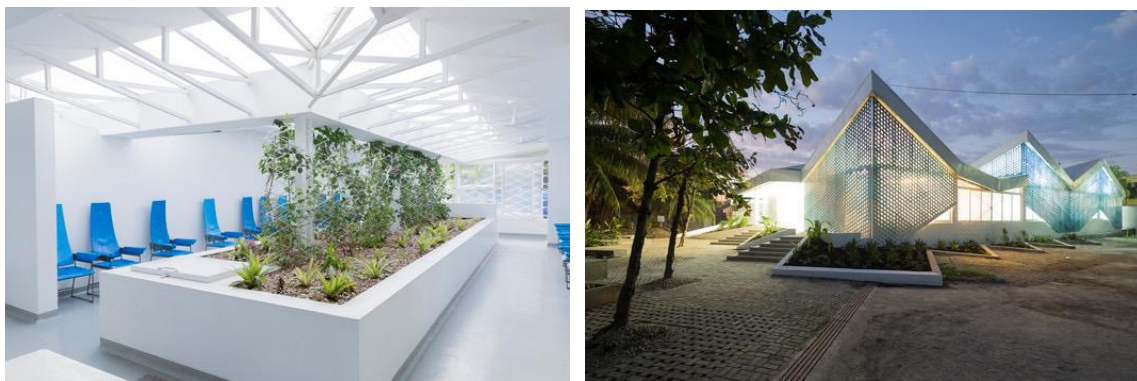


Fig 6. Cholera treatment center, MASS Design Group, The Republic of Haiti. © Iwan Baan.

In addition, it is necessary to pay attention to the relationship between the illumination level of the building space and the color temperature, which is an important factor in light healing and usually needs to be considered comprehensively. The relationship between the comfort of light color and the level of illumination is shown in the attached Figure 7. As can be seen from the attached Figure 7, the light with low color temperature at low illumination makes people feel happy and comfortable. High-color temperature light at low illumination will make people feel gloomy, dim, and cool feelings, and at high illumination will make people feel comfortable and happy [12]. Therefore, in the design of light healing in desert areas, the illumination factor can be combined to choose the appropriate color temperature and illumination.

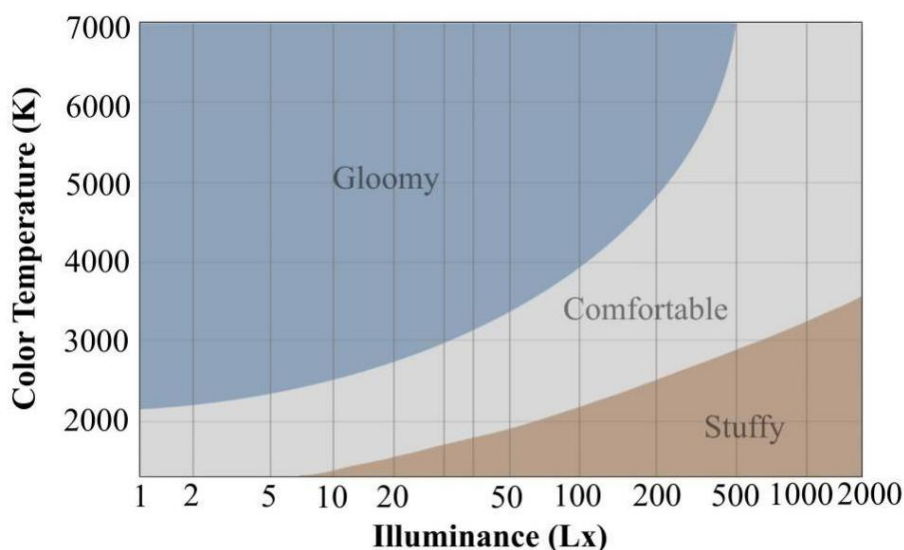


Fig 7. The relationship between horizontal illumination and comfortable color temperature. Redraw according to [12].

Secondly, the artificial light lighting design of buildings in desert areas needs to combine direct lighting and indirect lighting in both flexible and suitable ways. Through the combination of different ways, it is useful for designers to achieve the lighting effect and meet the relevant requirements of the specification. For instance, the design case of Chunjian Panda NANA in Fujian, China, is called Hoormem Light Healing Space. In this program, the designers combined direct lighting and indirect lighting to provide a warm and soft atmosphere by creating a low illumination and low color temperature effect. Specifically, the designers used a light projector, chandelier, indirect lighting, and indirect strip lighting of various heights, flooding light and diffusing reflection in many parts of the room. This method creates a hazy and comfortable feeling to achieve a relaxed and gentle psychological healing experience (attached Figure 8). In desert areas, the texture of desert dunes is relatively soft, so it gives people an easy feeling. Therefore, designers can combine dunes' features with a variety of lighting designs, such as the overall space using soft indirect lighting form, combined with key lighting in important areas to highlight the functional characteristics of the scene.

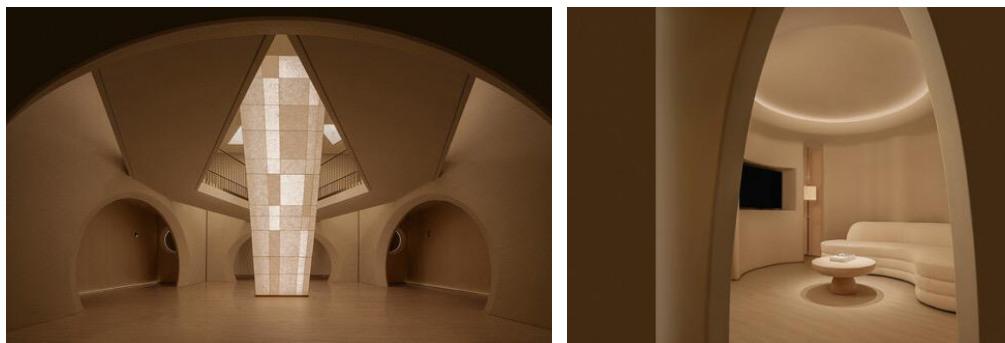


Fig 8. Hoormem muscle research aesthetic center, Cunjiang Panda NANA, Fujian, China. © Yanyu architectural space photography.

4. Summary

This research focuses on the application of light healing design in architecture of desert areas. Through literature review and case analysis, environmental advantages such as ample daylight conditions, diverse dune forms, the coexistence of multiple landscapes, and distinctive vegetation in desert areas are revealed, and the potential of combining these advantages with light healing design is analyzed. Furthermore, this study further discusses the lighting needs for people's activities in space based on the needs of people in the desert area and puts forward the application strategy and methodology of light healing design suitable for desert areas. Specifically, two light healing methods suitable for desert areas were discussed in this study: daylighting and artificial lighting. These methods aim to make full use of the light resources in the desert area and create an ideal light-healing environment that is beneficial to the physical and mental health of the people residing in a desert environment.

This research not only enriches the theoretical system of light healing design but also provides new ideas and methods for architectural design and spatial planning in desert areas. Through this research, people can more deeply understand the great potential and value of implementing light healing design in desert areas, and promote innovation and development in related fields, such as enhancing the aesthetic value and cultural connotation of desert buildings. In addition, the results are important for improving the quality of life of the people who are in the desert and promoting sustainable development, by regulating people's emotional state, relieving stress, and promoting physical and mental health. Looking forward to the future, there is still a broad space and prospect for the use of light healing design in architecture in desert areas. At the same time, with the advancement of science and technology and the development of new materials, the future can further pay attention to how the innovation of light healing technology is combined with the desert environment and explore more distinctive design schemes. Therefore, it is of great significance to promote and apply light healing design in architectural practice in desert areas.

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