

The Demand and Optimal Design of Light Environment for the Elderly under Aging Environment

-- Take Dalian xxx Retirement Center as an Example

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Abstract: With the increasing aging, the elderly need to be treated by "sunshine". Through field investigation, it is found that the interior corridor layout and the end of the corridor are windowless, resulting in poor ventilation and lighting. After the software simulation analysis and optimization design, the simulation experiment results show that the illumination and evenness of the public activity space have been improved, so that the overall lighting effect of the inner corridor without direct lighting has been significantly improved, and the natural light distribution is more uniform, providing a more comfortable living environment for the elderly.

Keywords: Light Environment; Suitable for Aging; Elderly Care Facilities; Software Simulation.

1. Introduction

Under the background of aging, this paper deeply discusses the specific needs of the elderly for the light environment, and takes a pension center in Dalian as an example to carry out field investigation and optimization design. In the process of research, we pay special attention to the specific needs of the elderly for the light environment due to the deterioration of vision and the change of psychological characteristics, and explore how to meet these needs through architectural design means to improve the quality of life and living experience of the elderly. With the intensification of the aging trend and the improvement of people's requirements for quality of life, it is believed that there will be more research and practice on the needs of light environment for the elderly in the future, so as to provide more beneficial references and references for the living environment and quality of life of the elderly.

2. Problems in Elderly Care Buildings

At present, the global population aging trend is irreversible, and it is expected that by 2050, the elderly over 60 years old will account for 12 percent of the global population[1]. The aging of the population is becoming increasingly serious, and it is urgent to solve the problem of providing for the elderly.

Aging needs to be treated with "sunshine". The World Health Organization proposed "active aging" in 1996, and it was written into the "political declaration" at the second World Assembly on Aging of the United Nations in 2002. Active aging aims to ensure that the elderly have a healthy body and keep a sunny mind[2]. With the gradual increase of age, the elderly's vision has obvious signs of decline, but most of the aging buildings in the interior design will not be based on the user's age design, therefore, in the case of the elderly's vision decline, the introduction of natural light and artificial light source becomes particularly important.[3]

3. Case Study of the Light Environment of Elderly Care Facilities

3.1. The Demand of Light Environment for the Elderly in China

3.1.1. Needs Arising from Visual Changes

As the elderly age, the pupil regulation function gradually weakens, and this change often leads to problems such as smaller pupils, decreased visual acuity, reduced light and dark adaptation, and reduced glare and contrast sensitivity. These issues not only affect their visual experience, but can also have a negative impact on the safety and convenience of daily life. In order to compensate for these visual degradation, the living space illumination of the elderly often needs to be 2-3 times higher than that of the young to ensure that they can get enough light during activities and reading to maintain a good quality of life and visual health.

3.1.2. Needs Arising from Psychological Characteristics

The special needs of the elderly for the light environment are also reflected in the psychological level, they are more inclined to natural lighting rather than electric lighting. However, due to the limitations of physical conditions and weather reasons, the elderly spend less time in outdoor activities, resulting in insufficient time for them to receive natural light exposure every day, and the total amount of bathing natural light is seriously insufficient. Therefore, after entering the old age, most people will have the phenomenon of circadian rhythm disorder. Therefore, the buildings where the elderly live for a long time need to provide sufficient indoor natural light intensity and light time to strengthen the circadian cycle of the elderly, so as to effectively improve these disorders. Reasonable light environment design can help regulate the sleep quality of the elderly and reduce anxiety, thus improving their overall quality of life and happiness.[4]

3.2. Relevant Regulations on the Light Environment of Elderly Care Facilities in China's Architectural Design Code

Table 1. Regulations related to the use of spatial light environment by the elderly in China's current standards and norms (summarized by the author according to relevant norms)

Standard name and number	The contents related to the elderly care environment in the standard
Design Standard for Elderly Care Facilities, JGJ 450-2018[5]	7.3.2 The illumination value of living room, recreation and fitness room and auxiliary space shall comply with the provisions of Table 7.3.2. The light source should be warm and energy-saving light source, the relevant color temperature should be less than 3300K, the color rendering index should be greater than 80, and the glare index should be less than 19.
Design Standard for Elderly Care Facilities, JGJ 450-2018[5]	5.2.1 The living room shall have natural lighting and natural ventilation conditions, and the sunshine standard shall not be lower than 2h sunshine hours on the winter solstice. When the sunshine standard of the living room is 2h lower than the sunshine hours of the winter solstice, the sunshine standard of the elderly living space shall be determined in accordance with one of the following provisions: 1. The sunshine standard of the unit living room in the same care unit should not be lower than 2h sunshine hours on the winter solstice. 2. The sunshine standard of at least one living space in the same living unit should not be lower than 2h sunshine hours on the winter solstice.
Construction Standards for Community Day Care Centers for the Elderly [with Explanatory Provisions] JGJ 143-2010[6]	Article 27 The rooms of community day care centers for the elderly shall ensure sufficient sunshine and good ventilation. Make full use of natural lighting, window to ground ratio should not be less than 1:6.

3.3. Field Investigation and Reflection on Lighting in Investigation -- Dalian xxx Pension Center

The orientation of the room is one of the first factors affecting the lighting. Through reasonable choice of room orientation and optimization of window design and treatment, the lighting effect inside the building can be enhanced, and a bright and warm living atmosphere can be created for occupants. The research case is located in Dalian, which is in the north temperate zone. For the room facing south, the reasonable window design can make more sun rays slanted into the room and keep the room warm and sunny. In the north-facing room, sunlight cannot enter the room directly, so the lighting is the worst. In this research, as the most frequent daily use of the elderly bedroom adopts one room and one window, and the use of a single light source lighting will inevitably have a lot of dark corners in the house, the elderly may not be able to see the furniture or facilities in the dark environment and cause accidents.(Figure 1)



Figure 1. North room
(Source: Photo by the author)



Figure 2. Inner corridor
(Source: Photo by the author)

The room area of the nursing home is usually small, so for the elderly, the corridor is not only a traffic channel, but also

an important activity and communication space. In the investigation, it is found that the interior corridor layout and the lack of Windows at the end of the corridor are two factors, resulting in poor ventilation and lighting conditions in the corridor. This kind of environment not only makes the corridor appear dark and stuffy, but also has a significant adverse effect on the physical and mental health of the elderly. In order to improve the situation, it is recommended to increase the introduction of natural light and improve ventilation conditions when designing and remodeling nursing homes. (Figure 2)

3.4. Greenville Software Simulates and Analyzes the Light Environment

3.4.1. Daylighting Optimization Design of Elderly Care Facilities

1. Open the closed rooms on both sides of the corridor, so that the linear corridor with no window at the end can obtain direct lighting and ventilation, and expand the activity area can provide more entertainment facilities for the elderly, such as setting up chess and card rooms, reading rooms, etc. The elderly can play chess and read books together in their spare time to enrich their minds.

2. Part of the activity room of the north side lighting is changed from closed to open, which not only increases the indirect lighting area of the corridor, but also enriches the flow of activities of the elderly. The scope of activities of the elderly is no longer limited to the activity room, adding vitality to the space.

3. Due to the large space of the activity room, it is difficult to ensure the uniformity of indoor lighting. In order to solve this problem, we can increase the number of Windows on both sides of the activity room. By setting up multiple window units, the uniformity of lighting can be effectively guaranteed.

After optimization, except the stairwell and elevator room (the bathroom is not included in the lighting standard), the lighting of all other rooms reaches the standard.

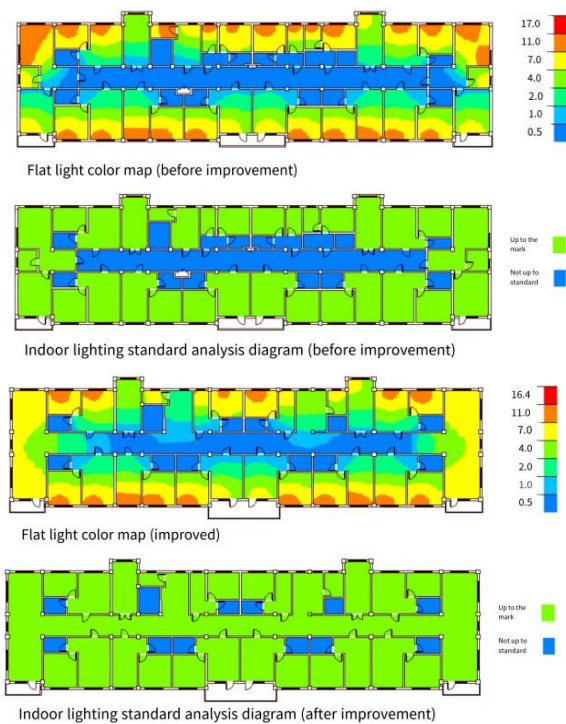


Figure 3. Light environment analysis diagram

(Source: The author used green building software to draw herself)

3.4.2. Analysis of Simulation Results

According to the simulation results, it is observed that the illumination and uniformity of the public activity space are obviously improved. This improvement can be attributed to the strategic location of the open activity room in the northern section. By reducing the area's reliance on artificial lighting, the light distribution throughout the interior corridor is more balanced and natural.

The introduction of the open activity room not only enhances the overall lighting effect, but also adds a sense of rhythm to the traffic space. Linear corridors that previously lacked visual interest now benefit from the new openness and dynamism. This transformation creates a more attractive environment for the individuals who pass through or use the space.

In addition, by breaking with the traditional design approach that prioritizes function over aesthetics, this innovative solution successfully eliminates any monotony or dullness associated with linear corridors. Instead, it introduces an element of surprise and excitement as people navigate the different areas of this common area.

Taken together, these findings highlight how thoughtful spatial planning and consideration of natural light sources can greatly enhance the practicality and ambiance of a building design. By incorporating an open activity room, improved illumination and uniformity not only helps to improve visibility, but also creates a visually appealing atmosphere for the elderly to enjoy their activities in this communal environment.

4. Conclusion

In the first part of this paper, the data of population aging in the seventh population census is refined and analyzed

comprehensively. This analysis not only provides a clear understanding of the current situation of population aging but also highlights its significance as a research topic. By clarifying the foothold of our research, we aim to contribute to existing knowledge on elderly care facilities and their impact on the well-being of older adults.

Moving on to the second part, we delve into exploring the specific demands that older adults have for their living environment, particularly focusing on light environment requirements. Through extensive field investigations and surveys conducted in various elderly care facilities, we identify several issues related to lighting conditions. These findings serve as valuable insights for further investigation.

To address these issues effectively, we employ green building software to analyze different case studies in elderly care facilities. By creating detailed light distribution maps based on this analysis, we gain a comprehensive understanding of how natural light is distributed within these spaces. Building upon this knowledge and considering practical constraints, we propose optimizations that can enhance both the overall livability and uniformity of natural light distribution within these environments.

Ultimately, our goal is for this research study's conclusions to provide valuable references for future architectural design endeavors aimed at meeting the needs of an aging population. We firmly believe that through scientific architectural design principles and meticulous planning regarding light distribution strategies, significant improvements can be made in enhancing living environments for older adults.

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