Simulation Study of Window Size on Indoor Lighting of Old-age Buildings

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Abstract. With the rapid development of China's society, the aging of the population has gradually developed into a hot issue of society. The degree of aging has intensified. The old-age environment of the elderly has gradually become the focus of social attention, and the natural light environment is an important part of the old-age environment. Its role cannot be ignored. Based on the light and climate characteristics of the severe cold regions of Xinjiang, this paper uses the light environment simulation software Ecotect to analyze the influence of window-to-wall ratio and window height on the interior lighting of the building, and improve the indoor light environment of the building by changing the size of the window and the height of the window sill. Further suggestions are proposed to improve the light environment of the nursing home.

1. Introduction
With the rapid development of China's social economy, the living patterns of the elderly in today's society have undergone great changes. For the elderly, the need for the elderly is not only a place for the elderly, but more importantly, older people provide an environment that is suitable for their physical and mental health. Therefore, the old-age environment of the elderly has gradually become the focus of social attention, and the natural light environment as an important part of the old-age environment, its role cannot be ignored. Natural light is an indispensable part of human survival. A good natural light environment can enhance people's comfort and bring sensory and psychological pleasure to users. Aiming at the needs of the elderly population for the light environment, reasonable natural light environment design is inseparable from the behavioral habits of the elderly. For the elderly buildings, research on the light environment is indispensable.

There are many factors that affect the natural lighting of buildings. In order to provide the best indoor environment for the interior of the building, it is necessary to make full use of natural lighting by changing the size of the building window, thereby reducing artificial lighting and saving resources. At the same time, it improves the comfort of the light environment of the elderly. This paper briefly explores the influence of the window shape and the height of the window sill in the cold regions of Xinjiang on the indoor lighting of the elderly.

2. Model building

2.1. Model overview
This paper selects the 1# building of Tianjian Nursing Home, located in No. 22 Community, Beiwu Road, Shihezi. As shown in Figure 1, the nursing home is a large nursing home combined with
medical care. The 1# building was completed in November 2011 and has five floors. The plane is L-shaped, with inner corridor type combination, building area of $5773 \text{ m}^2$, 300 old-age beds, living room with 2-3 persons, size 3.9mx6.8m; individual rooms are 5 people, size is 7.8mx6.8m, layer The height is 3.3m. Select one of the bedrooms as the research object, and the model is built as shown in Figure 2.

![Figure 1 Tianjian Nursing Home](image1.png)

![Figure 2 Room Model](image2.png)

2.2 Software selection
The simulation calculation software adopts Ecotect2010, and the software lighting calculation adopts the CIE full cloudy model, that is, the situation under the most unfavorable conditions. The analysis adopts the lighting coefficient as the index, and the lighting method is calculated by the item method. The sub-item assumes that the natural light at any point in the room contains three separate components: the sky portion (SC), the external reflected light component (ERC), and the reflected light component (IRC). The indoor lighting coefficient is the above three. The sum of the parts, through the daylighting coefficient and the outdoor design sky illumination, can calculate the working surface illumination. The height of the working surface of the simulation analysis is the height of the window sill. A calculation grid is set every 0.1m at the working surface. The number of grids is $39 \times 33$, which are 39 calculation points in the opening direction and 33 calculation points in the depth direction. All the calculation points form a calculation grid, which simulates the calculation of the natural daylighting coefficient values in the building under different working conditions. In order to simulate the distribution of natural daylighting coefficient with depth in different working conditions, the value of the daylighting coefficient of the measuring point in the center of the window is taken as the value of the daylighting coefficient, and the data of these daylighting coefficients are processed and compared.

2.3 Working conditions settings
This paper mainly studies the influence of different window-to-wall ratio and window sill height on the natural lighting of the aged building, and compares the curves of the depth of the lighting coefficient obtained under different working conditions to obtain the best window wall. Ratio and height of the window sill. The settings for different simulation conditions are shown in Table 1.

| Working condition | Window size (m) | Window sill (m) |
|-------------------|----------------|----------------|
| 1                 | 1.5×1.8        | 0.9            |
| 2                 | 1.8×2.1        | 0.9            |
| 3                 | 2.1×2.4        | 0.9            |
| 4                 | 1.8×2.1        | 0.8            |
| 5                 | 1.8×2.1        | 0.9            |
| 6                 | 1.8×2.1        | 1.0            |
3. Simulation result analysis

3.1. Comparative analysis of the influence of window-to-wall ratio on natural lighting

The window is located on the south facade of the building, and the window sill is 0.9 meters high. Under the premise that the height of the window sill does not change, the window-to-wall ratio is changed, for three windows (1.5×1.8), (1.8×2.1) and (2.1×2.4). The simulation analysis was carried out separately, and the distribution table of indoor lighting coefficient at different working face and window ratio was obtained, as shown in Table 2.

| Window size (m) | Depth (m) | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | Average daylighting coefficient (%) |
|----------------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------------------------------|
| 1.5×1.8        |           | 27.19 | 13.08 | 6.74 | 4.05 | 2.59 | 1.89 | 1.44 | 1.22 | 1.01 | 0.89 | 0.85 | 0.79 | 0.73 | 4.81                                 |
| 1.8×2.1        |           | 27.71 | 14.32 | 8.68 | 5.05 | 3.73 | 2.64 | 2.17 | 1.74 | 1.46 | 1.27 | 1.18 | 1.07 | 1.02 | 5.54                                 |
| 2.1×2.4        |           | 34.61 | 20.55 | 12.92 | 8.04 | 5.86 | 4.06 | 3.38 | 2.63 | 2.23 | 2.05 | 1.76 | 1.62 | 1.53 | 7.78                                 |

The data processing of Table 2 is carried out to obtain a graph showing the variation of indoor lighting coefficient with depth in different window walls, as shown in Fig. 3.

As shown in Table 2 and Figure 3, when the window sill height is 0.9 m and other conditions are the same. The larger the window-to-wall ratio, the larger the average daylighting coefficient of the building interior, indicating that the effect of the window-to-wall ratio on the indoor lighting effect is still relatively large. In the depth of 2.5m, the larger the window-to-wall ratio, the better the indoor lighting effect. As the depth increases, the variation of the indoor lighting coefficient value tends to be gentle, the change is not large, the indoor lighting coefficient is similar, and the lighting effect is also the worst. Regardless of the ratio of window to wall, the overall trend changes with the increase of depth, the change of the value of daylighting coefficient tends to be gentle, and the room with relatively large window wall is deeper than the room with smaller light-emitting coefficient than window-wall ratio. The value of the daylighting coefficient is much larger, which is more conducive to more deep lighting. Of course, in the severe cold regions of Xinjiang, it is not feasible to consider indoor lighting effects. It is also necessary to give due consideration to the problem of building energy consumption. Therefore, it is not possible to increase the window-to-wall ratio in pursuit of indoor lighting effects, and should also consider the problem of building energy consumption. In addition, as an old-age building, the needs of the elderly for the light environment should also be considered. When designing the old building, it is better to choose the appropriate window wall than to select the outer window.

Figure 3 Distribution of daylighting coefficients at different window and wall ratios

Figure 4 Distribution of daylighting coefficient at different window sill heights

3.2. Comparative study on the effect of window sill height on natural daylighting

The model is the same as above, the window is located on the south facade of the building, with a window width of 2.1m and a height of 1.8m. In the case where the width and height of the window are...
the same, the height of the window sill is 0.8m, 0.9m and 1.0m respectively, and the indoor lighting coefficient distribution table at different heights of the window sill at the working surface is obtained, as shown in Table 3.

Table 3 Distribution of indoor lighting coefficient at different window sill heights

| Window size(m) | Depth(m) | Average daylighting coefficient(%) |
|---------------|---------|-----------------------------------|
|               | 0.5     | 1.0                               |
| H=0.8         | 27.86   | 14.95                             |
| H=0.9         | 27.71   | 14.32                             |
| H=1.0         | 27.35   | 14.25                             |

Data processing on the above table yields a graph of the indoor lighting coefficient as a function of depth at different window sill heights, as shown in Figure 4.

As shown in Table 3 and Figure 4, under the condition that the size of the window and other conditions are the same, as the height of the window sill increases, the average daylighting coefficient at the working surface decreases, but the reduction is small, for different heights. The window at the depth of the window is about 2.0m. With the increase of the window sill, the lighting coefficient is decreasing and the reduction is large. After more than 2.0m, the lighting coefficient is gradually increasing with the increase of the height of the window sill. However, when the depth reaches 4.5m, the room lighting coefficient values of different window sill heights tend to be the same, the change is not obvious, and the indoor lighting effect is also the worst. Almost no light enters the farthest depth, and eventually tends to be gentle. Therefore, in the design of the building, the height of the window sill should not be too high, although the height of the sill is too high for the large light in the depth, but the excessively high windows affect the overall lighting level of the room, and also block people's sight, so in When designing the height of the window, it is also necessary to take into account both visual comfort and overall lighting levels. For the aged building, the influence of the cold air infiltration in winter should be fully considered to select the appropriate window height.

4. Conclusion

There are many factors affecting the natural lighting in the building interior. This paper only discusses the influence of the window-wall ratio and the height of the window sill on the natural lighting of the aged building. Get the following suggestions and conclusions:

Under the condition that the height of the window sill and the light transmittance of the glass are the same, the window and wall have a greater influence on the indoor lighting coefficient. In the depth of 2.5m, the indoor lighting coefficient value decreases greatly with the increase of the depth. With the increase of depth, the reduction of the indoor lighting coefficient value has been reduced, and the change tends to be gentle. Generally speaking, the window size has a greater influence on the indoor lighting effect.

Under the same conditions of window and wall ratio and glass transmittance, the natural lighting effect in the building room decreases with the increase of the height of the window in the depth of 2.0m, but the height of the window increases after more than 2.0m. It is beneficial to the lighting effect of the deeper depth. Therefore, although the window is too high, it is beneficial to the lighting of the deeper depth, but it affects the overall lighting effect and the visual comfort of the building. Therefore, the architect is designing the window. The height of the window sill should be properly considered during the process.

For the elderly group, there are many factors affecting the comfort of the light environment. It is often the interaction of these factors and organic regulation to provide a comfortable light environment for the elderly. This paper mainly studies the window-to-wall ratio and the height of the window sill to the building. The influence of indoor lighting, but in addition to the factors of the window itself, there are many factors that affect the indoor natural lighting, such as the occlusion of the surrounding environment of the building, the decoration of the building interior, the exterior shading of the building, will be carried out in the follow-up study.
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