Indoor Environmental Quality Assessment and Building Shading Measures Research

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Abstract. This paper starts with the evaluation of indoor environmental quality, and on this basis, analyzes the relationship between human comfort and various environmental factors, establishes a temperature-comfort evaluation model, and uses ECOTEC software to correlate according to the evaluation results of influencing factors. The laboratory simulation of the energy-saving measures for building shading shows that the temperature parameter is an important indicator for evaluating comfort. The relevant optimization measures such as building shading can not only save energy, but also significantly improve the environmental comfort.

Introduction

China's current green building assessment system puts forward higher requirements and standards for indoor environmental quality, indoor environment comfort and building energy conservation. Comfort is not a single feeling, but a combination of people and the environment, with a combination of environmental factors[1]. Therefore, we collect the environmental parameters we need under appropriate conditions, make an accurate assessment of the excellent indoor environment, and associate it with comfort to complete the evaluation of comfort.

This paper starts with the evaluation of indoor environmental quality, and analyzes the relationship between human comfort and various environmental factors, establishes a temperature-comfort evaluation model, and uses ECOTEC software to carry out relevant energy-saving measures based on the evaluation results of influencing factors. The laboratory simulation shows that the use of three-dimensional information technology to assist the design of the building can not only improve the design efficiency, but also make the design of the building more reasonable and the user more comfortable.

Determination of Environmental Quality Assessment

In the comprehensive environmental assessment, determining the membership function is an extremely important part, which largely determines the accuracy of data fusion[2]. In this study, the Cauchy distribution was used to calculate membership.

\[ r_{ij} = \begin{cases} 1, & x_i \leq a_{ij} \\ 1/1 + a(x_i - a_{ij})^\beta, & x_i > a_{ij} 
\end{cases} \quad (a > 0, \beta > 0) \]

(1)

According to the principle determined by the above comment set, combined with the relevant specifications, the membership degree of each sensor is set separately, and the normalized analysis is completed to obtain the fuzzy relationship evaluation matrix R:
Evaluation Results

Through the above steps, obtain the required index weights and evaluation matrix, and then we can complete the fuzzy comprehensive evaluation of the target environment.

According to the obtained weight set and the comprehensive evaluation matrix, the following table 1 is calculated by the relevant program:

Table 1. Evaluation results.

| Parameters | Excellent | Good | Medium | Poor | Very poor | Results |
|------------|-----------|------|--------|------|-----------|---------|
| result     | 0.329     | 0.344| 0.283  | 0.025| 0.017     | Good    |

It can be seen from the above table that the stratified analysis and fuzzy analysis are used for comprehensive evaluation, and the monitored environmental quality is good.

Indoor Environmental Quality and Comfort Relationship

Based on the results of the previous analysis, can know that the indoor environment of the building is of good quality[3]. For the satisfaction of environmental comfort, have established the evaluation scale shown in Figure 2.1 below. Based on their true feelings, people find the appropriate scale corresponding to the scale according to the current comfort feeling and complete the relevant mark. “-1” means dissatisfaction, “+1” means satisfaction, and “+0” is above, it is considered that people are satisfied with the environment, and gradually increase from “+0” to “+1”, and satisfaction is corresponding taller and taller.

![Satisfaction rating scale for environmental comfort](image)

Figure 1. Satisfaction rating scale for environmental comfort.

Indoor Thermal Environment Research

In this context, the monitored indoor environmental parameters include temperature and humidity. According to the results analyzed in the previous paper, in this study, the index weights of five types of indoor environmental quality factors (temperature, humidity, formaldehyde, TVOC, PM2.5) were first determined. The change in temperature is directly subject to the illumination of the exterior of the building and the energy consumption of the air conditioning system inside the building. Therefore, in the data analysis, establish a functional relationship between temperature and thermal environment. Using SPSS to analyze the data, we can find from the parameter evaluation table below that the R-square value of the fitted quadratic model is 0.736, indicating that the quality of this regression function is very good. The following table also outputs regression model parameter results, as shown in Figure 2.

| Equation | Model summary | Parameter estimate |
|----------|---------------|--------------------|
|          | R side        | F                  | df1 | df2 | Sig. | constant | b1 | b2    |
| Second time | .736       | 25.108             | 2   | 18  | .00  | -3.089   | .302| -.007 |
| S^a       | .307        | 4.187              | 2   | 18  | .05  | -1.810   | .309| -.007 |
The quadratic regression fitting analysis is carried out on the collected temperature value and the thermal environment satisfaction scale value at this temperature. The specific functional relationship between the two is:

\[ S_t = 0.302t - 0.007t^2 - 3.089 \]  

(3)

The output plot scatter plot is:

![Scatter plot of thermal environment satisfaction and temperature](image)

Figure 2. Thermal environment satisfaction and temperature curve.

According to the obtained relational expression, the characteristic values of the function are analyzed. When the temperature is 21.57 °C, people are most satisfied with the comfort of the thermal environment in the area.

**Impact of Energy-Saving Optimization Design on Indoor Thermal Environment**

Based on comprehensive analysis, external shading plays a significant role in energy-saving design because it reduces the direct light of the summer to reduce the load on the air conditioning system and improves the indoor thermal environment of the building, making the lighting more uniform and improving the quality of the light environment. In the study, the third layer of the building (the standard layer) was selected for analysis and research. The model is shown in Figure 3. Import the model into Ecotect for analysis. The results are shown in Figure 4.

![Three-layer BIM model](image)

Figure 3. Three-layer BIM model.

![Effect diagram imported into Ecotect](image)

Figure 4. Effect diagram imported into Ecotect.

It can be seen from the above experimental results (Table 2,3) that the window without the sunshade member is compared with the case of adding the member. The maximum amount of radiation when not in use is 514495.22Wh. After using the sunshade member, and the effect of the wraparound sunshade is most obvious, with a solar radiation of only 45%. 
Table 2. Comparison of light simulation before and after the use of sunshade components.

| Shading application | Radiation simulation analysis chart | Average solar radiation (Wh) |
|---------------------|-----------------------------------|----------------------------|
| No sunshade member  |                                   | 51495.22                   |
| Vertical sunshade   |                                   | 498644.28                  |

As can be seen from the information in the figure, the comfort zone is at 18-26 °C, and the average temperature is about 21.2 °C, which is higher than the average temperature collected before the energy-saving optimization design is 0.9 °C. According to the comfort evaluation model established before, the comfort is best when the temperature is 21.57 °C, and the average temperature after the energy saving optimization is close to the optimal comfort, and the average temperature is higher than the previous one. It can be concluded that after the optimized design, the building makes better use of the solar radiation brought by the orientation and fully utilizes the insulation of the enclosure structure, so the comfort is significantly improved.

**Ecotect-Based Comfort Simulation Analysis**

Using Ecotect software, the monthly discomfort can be calculated according to the setting of the parameter environment. The specific values are shown in Figure 5. The value is in Degree Hours, which is hour. It is the result of subtracting the limits of all uncomfortable temperatures from the comfort temperature.

**Figure 5. Analysis of discomfort data imported into Excel.**
According to the above analysis, compared with the energy-saving optimization strategy, the discomfort after using the relevant optimization measures is reduced. This shows an optimized building orientation, sunshade assembly and fixed structure for added comfort. This is consistent with previous analysis.

**Conclusion**

According to the indoor environment monitored, combined with multi-factors, the combination of analytic hierarchy process and fuzzy evaluation is used to comprehensively assess the environmental quality. According to the analysis results, temperature is used as an important index to evaluate comfort. SPSS is used to establish the relationship between satisfaction and comfort, and then the comfort prediction model is obtained. Ecotect is used to simulate the temperature change after energy saving optimization, and the model is comfortable according to the established model. Sexual changes, and finally through the Ecotect simulation of energy-saving measures before and after the discomfort, to further verify the reliability of the results.

**References**

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