Application of Computer-based Simulation Analysis in Green Architecture Design

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Abstract. Through simulation calculation of sunshine, wind field and noise in Lize Financial Business District, it is suggested that natural light should be introduced into the room to make up for the influence of insufficient sunshine, or lighting fixtures with low energy consumption should be selected for artificial lighting., land owners should design solar photovoltaic power generation properly, an open structure should be adopted at the bottom of the annex building to guide the natural wind and enhance the ventilation. According to the sound insulation requirements at different heights of buildings and those in different facade directions at the same height, sound-proof windows made of different materials with different performance should be selected to ensure the maximum use of natural lighting and ventilation, energy conservation and environmental optimization of buildings in the region, meeting the requirements of people for indoor and outdoor comfort.

Keywords: Computer-based Simulation, Green Architecture, Wind Environment, Sunshine Environment, Acoustic Environment

1. Introduction
China's economy is in a high-speed development stage, people's living standards are continually improving, and the living environment is gradually improving. In recent years, the construction industry has developed rapidly. In the future, there are still a large number of projects to start construction. On the one hand, it indicates that the urbanization process in China is advancing rapidly[1]. On the other hand, it has also imposed tremendous pressure on the environment. With the continuous expansion of the urban scale, the destruction of the urban ecological environment is becoming more and more serious, causing more harm to people living in it. In the whole life cycle of the architecture, the completion of the project is only the first stage. If the design and construction of the architecture are unreasonable, a large amount of energy will be wasted after completion[2-3]. China has a vast territory and uneven distribution of resources. In general, resources are still in the situation...
of energy shortage. It is necessary to maintain a sustained and steady economic development in China. Energy conservation and emission reduction are crucial issues to be solved urgently\(^4\). To this end, on the one hand, it is necessary to develop new energy, and more importantly. On the other hand, the efficiency of resource utilization should be improved. The energy consumption of existing buildings should be gradually reduced through energy-saving transformation, consider energy conservation and environmental protection when designing and architecture new buildings, and inject the design and Construction Philosophy of green buildings\(^5\)-\(^6\). Green architecture is closely related to the protection of the human living environment, which is the inevitable direction of future architecture development. Ecotect, CFD, urbanstrantagy software are used in this paper to simulate and analyze the sunshine environment, wind environment, and acoustic environment of the business district, and adjustment suggestions are put forward based on the simulation results.

2. Computer-based simulation analysis process

The application of computer-based simulation analysis system in construction engineering can make the construction process have a variable resource level and provide variable duration for activities. Part of the assignment of a computer-based simulation system to the activity means that the whole computer-based simulation system is part of the work, or the entire computer-based simulation system shares with other activities. To facilitate the simulation, we divide the computer-based simulation system into 10 parts.

The duration of a resource activity can be calculated as follows:

\[
D_i = \frac{w_i}{n_i} + M
\]

\(D_i\) represents the time required for resource I to complete the activity; the workload of resource is I; \(N_i\) represents the number of resource types; \(m\) represents the time required for construction.

Beside architecture resource constraints, the model also simulates the influence of supervision on work progress and productivity, where the exponential mathematical relationship between productivity and the ratio of the number of foremen to the number of staff are used. If there is no supervision, it assumes that productivity is the optimal 50% participation. Based on this assumption, the generation factor is calculated according to the following equation:

\[
P_F = 1 - \frac{0.5}{e^r}
\]

\(P_F = \) productivity factor:

\[
R = \frac{\text{Number of foremen}}{\text{Number of operatives}}
\]

The final duration of the activity can be further calculated as the maximum resource-based duration divided by the productivity factor indicated in equation 4.
\[ D = \frac{D_{(\text{max})}}{PF} \]  

3. Simulation analysis of sunshine environment

Pursuant to the relevant standards and specifications of the green architecture evaluation standard, combined with the spatial layout, functional positioning, the utilization requirements, and operation characteristics of the settled project, five requirements for physical environment quality indicators are proposed. The details are shown in Table 1. In this paper, the sunshine hours of full windows on the bottom floor of residential buildings from 8:00 to 16:00 on a cold day in a specific area are studied. The existing residential buildings in the business district include Lize Yayuan, Shunchi Landiao Community, Jintai Liwan Community, Jinduyuan community, Huiqian Community, and Wanquan Temple Residence. The overall sunshine condition of the project is excellent, and most of the architecture complex areas are less affected, but the new buildings in Lizeiyuan and Shunchi Landiao Community are severely blocked. By modeling and analyzing the existing residential buildings No.1 and No.3 on the south side of Shunchi Landiao Community, the sunshine time is 4.8, 4, 3.2, 2.4, and 1.6 hours, respectively. The full window sunshine hours of some residents in No. 1 residential architecture are less than 2 hours, while the sunshine hours at the windowsill of the bottom floor of No. 3 residential architecture meet the requirements of more than 2 hours.

**Table 1.** Definition of physical environment quality control index and simulation content of business district

| physical environment | No. index content | No. index content simulation content | No. index content simulation content |
|----------------------|------------------|-------------------------------------|-------------------------------------|
| Sunshine Environment | 1                | The sunshine hours of the existing residential buildings in the cold days are more than 2 hours | Simulation analysis of sunlight hours with full windows on the bottom floor of residential buildings |
| Wind environment     | 2                | Make full use of solar energy resources | Simulation analysis of sunshine hours on facade and roof of new buildings in winter solstice |
| Acoustic environment | 3                | 100% of the wind speed at 1.5m above the ground | Simulation analysis of wind speed, wind pressure and weak wind area in wind field |
| physical atmosphere  | 4                | Maximize natural ventilation | Simulation analysis of openable height of exterior window in super high rise architecture |
| Sunshine Environment | 5                | The construction noise meets the requirements of the standard, and the compliance rate is 100% | Simulation analysis of noise level of different height of architecture |

4. Acoustic environment simulation analysis

According to the special comprehensive traffic plan of Lize Financial Business District, the total length of various roads in the core area is 23.7 km, forming a "three-dimensional traffic" network pattern of one urban expressway (Lize Road), one main road (South Road of Beijing West Railway Station) and several branches.

Analysis of the acoustic environment shows that the noise generated in Lize Financial Business
District is over 75db, which exceeds the noise limit of the environmental quality standard for noise (gb3096-2008). Most of the plots in Lize Financial Business District have obvious noise exceeding the standard, and the noise in other sections meet the requirements.

4.1. Noise level distribution of the facade in different directions and preventive measures

Taking the nearest architecture to Lize road as an example, the noise in different directions of the architecture is simulated and analyzed (Table 2). Table 2 shows that the noise level is the highest because the south facade is along the street.

| Architecture site | East | South | West | North |
|-------------------|------|-------|------|-------|
| A-02              | 60   | 60    | 65   | 60    |
| A-08              | 65   | 75    | 65   | 65    |
| A-09              | 70   | 75    | 65   | 70    |
| A-10              | 65   | 75    | 70   | 70    |
| A-11              | 70   | 70    | 70   | 70    |
| A-12              | 70   | 70    | 70   | 65    |

4.2. Noise level distribution at different heights of buildings and preventive measures

Most of the Financial Business Districts in Lize are super high-rise buildings with varying levels of noise at different heights. The noise distribution in 40, 90, 150 m height area is predicted. The regional noise distribution below 40m first appears attenuation and increases with the increase of height from 40m to 90m, and the attenuation effect appears above 90m. The main reason is the decreasing trend with height. When the receiving angle is substantial at high altitude, the sound shielding effect becomes smaller and smaller with the height, and a broad range of sound sources will produce a superposition effect, which makes the noise distribution at high altitude change specifically. The buildings in Lize Financial Business District are dense, and the noise reflection is serious.

Activity-based ratio technology has also been used in experiments, as shown in Figure 1, which shows the cumulative efficiency of activities and the entire architecture. It can be seen that the efficiency of activities is superior to that of the whole architecture, which may be caused by waste or redundant indirect costs caused by many things such as materials. It also shows that the average efficiency of the whole architecture is 95% of the plan, which is almost the same image as other computer management charts.
Figure 1. Green architecture rendering after the application of computer analysis technology

5. Conclusions
Building energy conservation, emission reduction, and green architecture are integral parts of the sustainable development strategy in China. Architecture technicians should be involved in the planning and design stage, apply the computer-based simulation analysis technology to simulate and evaluate the scheme, and cooperate with architects to optimize the scheme so that the architectural design can meet the requirements of green architecture, thereby driving the large-scale development of green architecture in the region.

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