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OPTIMIZATION ALGORITHM FOR GREEN ENVIRONMENT DESIGN BASED ON ARTIFICIAL INTELLIGENCE

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Abstract. In order to build energy-efficient commercial buildings in bustling urban centers and utilize passive means such as natural ventilation and natural lighting as much as possible to improve indoor environmental quality, the author proposes a green environment design optimization algorithm based on artificial intelligence. Taking Building A as an example, simulation technology was used to optimize the performance of the enclosure structure, anti condensation in the glass atrium, and natural ventilation during the transition season. The sunlight and shadow simulation software BSAT was used to simulate the mutual occlusion and self occlusion of the building. It was found that external rolling shutters were not required for shading the facade between axes L2-L5 and 3-9. Using DeST-C, the energy consumption and investment of south facing, east facing, and west facing envelope structures were compared when using different types of glass. Combining economic efficiency and energy-saving effects, the optimal southbound enclosure structure scheme for this building is to use Low-e membrane coated hollow double glass with ten horizontal louvers for external shading; It is recommended to adopt the scheme of hollow double glass (Low-e membrane) or hollow double glass (Lowe membrane)+external roller shutter in the east-west direction. It is worth noting that for east-west oriented glass, the Lowe film should be low permeability, mainly to improve the thermal performance in winter and reduce the radiation heat gain in summer. Using DeST-C for simulation 2 calculation, it was found that when the thermal performance of windows increased from 3.0W/(m^2. K), shading coefficient 0.7 to 2.0W/(m ° K), and shading coefficient 0.5, the maximum cold and heat load of the building and the cumulative consumption of cold and heat throughout the year were significantly reduced, providing an effective reference for solving problems.

Key words: Artificial intelligence, Green environment, Design optimization algorithms, Energy saving, Enclosure structure

1. Introduction. Due to the high-density agglomeration of urban population and pollution caused by production and daily life, the ecological environment of urban residential areas is increasingly valued by people [1]. Green environment design is an important means of ecological environment design. Green environment design for residential areas can fully improve the climate characteristics of residential areas, and achieve unity and harmony with nature in the living environment of residential areas. Generally speaking, the form of green environment design in residential areas includes grassland greening, tree (tree, shrub) greening, balcony and terrace greening, interior and exterior corridor greening, exterior wall greening, roof platform greening, and indoor greening. It is a three-dimensional and all-round green environment. In residential areas, grasslands not only provide recreation, but also provide a broad view and become the center of public activities, serving as the "breathing space" of residential areas. But in some current residential areas, developers have made the central green space area too large in pursuit of grandeur, and there is a lack of coordination between shrubs and trees. Due to the limitation of the overall plot ratio, residential areas have reduced the green coordination of the adjacent green spaces, on the other hand, there is a lack of trees to shade the sun, resulting in a lack of humanized space in the central green space, which lacks a lot of fun and even becomes purely a decoration. Trees can absorb dust and noise in residential areas, reduce wind speed, preserve soil and water, and block the scorching sun in summer. On the landscape, it can enclose the space and block the view. Meanwhile, the oxygen production of trees is significantly higher than that of grass. When selecting tree species, attention should be paid to selecting trees that are suitable for the local climate, soil, and hydrological conditions, emphasizing the combination of common and precious tree species, the combination of deciduous and evergreen trees, the arrangement of tree clusters and clusters, and the selection of tree size, height, and morphology. The ecological environment of balconies varies greatly due to differences in their enclosed form, orientation, height, and shape. The main way of balcony greening is to place potted flowers inside the balcony and on the concrete handrails

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of the railing, and to build various types of planting slots in sync with the civil engineering project. It can be installed around and along the balcony railing, and can also be combined with the solid balcony railing to form a flower hopper groove shape. At the same time, various planting pots can be hung on the hanging board of the railing, which not only enriches the shape of the balcony railing, but also increases the function of planting flowers. At the same time, by setting up greenery on balconies and terraces, the building facade can be enriched, adding a moving and bright color to the building. In architectural design, flower beds and racks can be set up on balconies and terraces, with potted plants as the main greenery, accompanied by climbing plants, which should have strong ornamental value and can generally be floral plants.

Currently, energy conservation and improving indoor environmental quality are receiving increasing attention in architectural design. How to build energy-efficient commercial buildings in bustling urban centers and make the most of passive means (such as natural ventilation, natural lighting, etc.) to improve indoor environmental quality is of great significance for the sustainable development of China's construction industry. In the current development process of large-scale commercial buildings, due to excessive pursuit of aesthetic effects and consideration of eye-catching benefits in the early stage of investment attraction, glass curtain walls are extensively used as facade elements in building design, but the thermal effects and reasonable selection of glass curtain walls are not fully considered, often leading to the deterioration of building thermal performance, increased initial equipment investment, and high energy consumption of air conditioning system operation. At the same time, the summer solar radiation near the glass curtain wall is strong, and the average indoor radiation temperature is high; In winter, when the temperature is low and the radiation is strong, the indoor thermal comfort will significantly decrease. In addition, for the deep interior area, it is also necessary to consider how to effectively organize ventilation and cooling during the transitional season and improve indoor thermal comfort.

In order to avoid the problems that glass curtain wall buildings are prone to in building A, the author fully implemented the concept of energy-saving design in the early design stage, adopted advanced computer simulation technology, optimized the enclosure structure and passive natural ventilation design, and achieved certain results [2,3].

2. Methods. Project A is one of the renovation and construction projects for the commercial area on the west side of Xidan North Street in City A. It is located in the bustling center of the city, with a land area of about $16700m^2$ and a building area of about 200000 m^2. The design requirements meet various commercial activities such as large-scale commercial, high-end office, catering, entertainment, and hotels. The entire building is lightweight and transparent, using a large number of glass components to enhance the integration between humans and the natural environment; In addition, there is a transparent inverted cone atrium with a unique and prominent design, which can also serve as a natural ventilation channel. For such a super large commercial building, in order to avoid the problems that glass curtain wall buildings are prone to, the concept of energy-saving design was fully implemented in the early design stage. Advanced computer simulation technology was used to optimize the enclosure structure and natural ventilation passive design, and certain results were achieved. Here is a brief introduction.

2.1. Ventilation optimization design. Combining the characteristics of this building, we focus on using natural ventilation or mechanical assisted natural ventilation methods to solve the transitional season ventilation problems in most areas. The layout of various cinema buildings in Building A is relatively dense, making it difficult to organize natural ventilation. Therefore, it is recommended to use a full air system during the transition season to operate under full fresh air and full exhaust conditions [4]. Thermal natural ventilation (or mechanical assisted thermal natural ventilation) mainly relies on the tall inverted cone atrium in the middle of the building and the south side atrium space of the cross. Figure 2.1 shows the indoor natural ventilation node diagram. In order to ensure the effectiveness of thermal ventilation, a certain open external window area is required to construct a calculation program for the thermal fluid network, using meteorological conditions of typical days in the transitional season for calculation [5]. The calculation method is as follows:

① Select representative days for the transitional season, calculate the solar heat gain in the atrium and the internal disturbances in various functional areas;

② Estimate the appropriate natural ventilation rate to determine the temperature distribution (average air exchange rate) in the atrium; The temperature distribution can be determined according to a linear distribution relationship based on existing research results;

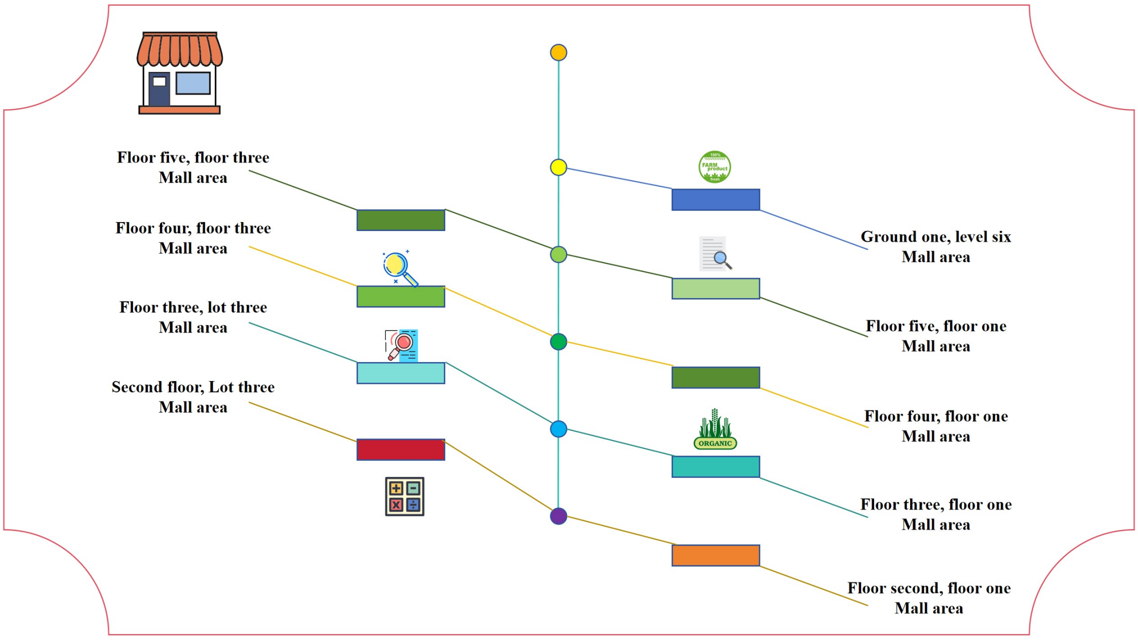

Fig. 2.1: Indoor Natural Ventilation Node Diagram

③ Using regional network method to calculate the natural ventilation flow rate of each branch, and guiding and optimizing building design; If there is a discrepancy between the calculated ventilation volume and the estimated value in , the estimated value in should be adjusted, and the above steps should be repeated to solve the calculation until the calculated value and estimated value match.

In this way, the openable window areas for different parts were calculated separately. The result is that the opening area of the north exterior window should not be less than $20m^2$/floor; The south and west sides of Building D must ensure that the opening area of the external windows on each floor is not less than $30m^2$; The first floor of building B should ensure that the opening area of the external windows is not less than $15m^2$. In addition, on the top of the south facing part of the cross courtyard, an outer window that can be mechanically controlled to open should be installed, and mechanical ventilation equipment should be installed to timely discharge accumulated heat under adverse working conditions. The exhaust equipment can be used in conjunction with the atrium smoke exhaust equipment. Due to the presence of mechanical equipment, the area of the external window that can be opened can be slightly smaller, but should not be less than $20m^2$. For the inverted cone atrium, mechanical control side windows are installed at the top of the twelfth and thirteenth floors, with a total opening area of not less than $50m^2$.

2.2. Energy saving design of exterior facade enclosure structure . Due to the fact that almost all of the peripheral protective structures in the original plan of this building were glass components (K value of about 3.0W/(m^2 ° K)), in the deepening design, according to the original building drawings and the functional and usage requirements of the space, glass curtain walls were minimized as much as possible, and walls (or designed as inner solid walls and outer glass) were added to improve the thermal performance of windows, reducing the drawbacks of operating load and high operating costs caused by the relatively poor thermal performance of too many glass curtain walls. Under this principle, for functional spaces such as shopping malls, elevator rooms, air conditioning rooms, fire centers, garbage stations, storage rooms, bathrooms, etc., the outer enclosure structure will be as solid as possible with some external windows added (some of which are mainly used for ventilation and lighting); Or design according to the combination of inner solid wall and outer glass. In addition, for areas with LCD screens and billboards on the facade, the corresponding exterior walls are also adjusted to solid

Table 3.1: Comparison of energy-saving effects and initial investment increase of different enclosure structure schemes in the south direction

	Hollow double glass +single glass+horizon- -tal shading (double-layer curtain wall)	Hollow double glass (Low-e film)+horizon- -tal shading	Hollow double glass (coated with ten inert gases) +horizontal shading
Annual cumulative energy savings /(kWh/$m^{2\circ}$(year))	56.3	75.6	90.7
Annual operating cost savings (yuan/($m^{2\circ}$ year))	39.4	53	63.5
New initial investment/ (yuan/m^2)	500	300	800

Table 3.2: Comparison of energy-saving effects and initial investment increase of different enclosure structure schemes in the east and west directions

	Hollow double glass +external rolling shutter	Hollow double glass+lou- -ver shading +single glass	Hollow double glass (Low-e membrane)	Hollow double glass (Low-e film)+exter- -nal roller shutter	Hollow double glass (coated with Low-e film)+louver shading+single glass
Annual cumulative energy savings /(kWh/($m^{2\circ}$ year))	84	92	77	119	119
Annual operating cost savings (yuan/($m^{2\circ}$ year))	59.1	64.7	54.2	83.6	83.6
New initial investment /(yuan/m^2)	150	500	300	450	800

walls. Using the sunlight and shadow simulation software BSAT for building mutual occlusion and self occlusion simulation, it was found that the facade between L2-L5 and 3-9 axes does not need to be designed with external rolling shutters for shading. However, for the 6th floor and above of Building C (including facades outside the 3-9 axis), it is recommended to design external roller blinds or other sunscreen measures. For Building D (office building), the facade below the seventh floor in the west direction and between the 1/2 axis of the 12-15 axis can be blocked by its adjacent buildings in the west direction between 15:00 and 17:00, and external rolling shutters can be omitted for shading.

3. Results and Analysis.

3.1. Energy saving design results of exterior facade enclosure structure. Using DeST-C, the energy consumption and investment of south facing, east facing, and west facing envelope structures were compared when using different types of glass. The calculation results for the south, east, and west directions are shown in Tables 3.1 and 3.2, respectively. The thermal performance parameters of various glasses are shown in Table 3.3 [6].

Combining economic efficiency and energy-saving effects, the optimal southbound enclosure structure scheme for this building is the combination of Low-e membrane coated hollow double glass and horizontal louver external shading; It is recommended to adopt the scheme of hollow double glass (Low-e membrane) or hollow double glass (Lowe membrane)+external roller shutter in the east-west direction. It is worth noting that for east-west oriented glass, the Lowe film should be low permeability, mainly to improve the thermal performance in winter and reduce the radiation heat gain in summer.

Using DeST-C for simulation 2 calculation, it was found that when the thermal performance of windows

Table 3.3: Thermal performance settings for different glass curtain walls

Glass type	Heat transfer coefficient K value/(W/($m^{2\circ}$K))	Sunshade coefficient SC
Ordinary hollow	3.1	0.71
Ordinary hollow+single glass (double-layer ventilation curtain wall)	2.1	0.54
Hollow coated with Low-e film	1.9	0.52
Inert gas filling+hollow coating	1.6	0.52
Low e hollow+single glass	1.5	0.41
Inert gas filling +coating hollow+single glass	1.3	0.41

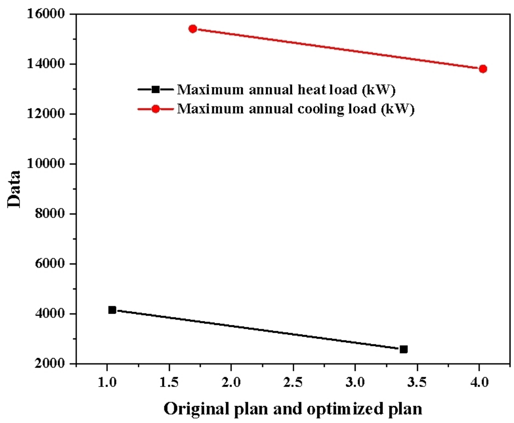

Fig. 3.1: Energy saving effect (load) of glass thermal performance optimization

increased from 3.0W/($m^2.K$), shading coefficient 0.7 to 2.0W/(m° K), and shading coefficient 0.5, the maximum cold and heat load of the building and the cumulative consumption of cold and heat throughout the year all decreased significantly, as shown in Figures 3.1 and 3.2 [7].

3.2. Analysis of Glass Inverted Cone Atrium Envelope Structure Scheme. The glass inverted cone atrium is located in the middle of this building complex. Due to the use of a full glass curtain wall structure, in winter, the outdoor temperature is very low, and the strong sky radiation at night at the top of the cone will cause a lower surface temperature inside the glass cone, which may lead to large-scale condensation [8-10]. Therefore, it is necessary to analyze the inner surface temperature of the glass cone during the most unfavorable working conditions in winter and make improvements. Using CFD simulation software PHONEICS to simulate and calculate the air temperature distribution inside the cone. The upper diameter of the cone is 28m, the lower diameter is 12.6m, and the height is 25m. The lower part is an opening, and the air entering the cone has a dry bulb temperature of 20 $^\circ C$, a relative humidity of 40%, a dew point temperature of 6 $^\circ C$, and an outdoor temperature of -10 $^\circ C$. The heat transfer coefficients of the inner and outer surfaces of the glass are 8.7W/(m^2 $^\circ$ K) and 18.6W/(m^2 $^\circ$ K), respectively. Considering the strong radiation heat transfer between the top of the cone and the sky at night, the heat transfer coefficient of the outer surface of the top glass is set at 30W/(m^2 $^\circ$ K). For a single glass, the comprehensive heat transfer coefficient is set at 6.0W/(m^2 $^\circ$ K), while for ordinary hollow double glass, it is set at 3.0W/(m^2 $^\circ$ K). It can be seen that indoor air at 20 $^\circ C$ rises from below, cools at the top, and then descends along the side and flows out of the cone. The air temperature inside the cone is around 12-15 $^\circ C$, and in some areas such as the area around the top of the

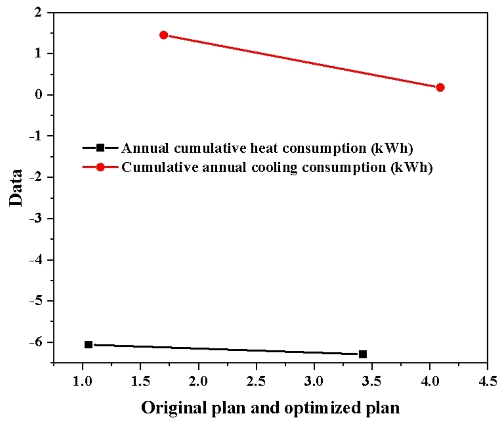

Fig. 3.2: Energy saving effect (heat) of glass thermal performance optimization

cone, the air temperature can drop to 8 $°C$. When the outdoor air temperature is -10 $°C$, according to the method of heat transfer resistance difference, the temperature on the inner surface of the glass cone is about 3 $°C$, and the temperature on the inner surface of the glass at the top of the cone is also very low, about 1-6 $°C$. The temperature on the inner surface of the edge area of the cone is relatively low, about 1 $°C$, and a higher value of 6 $°C$ can be reached at the center. Therefore, if a single-layer glass scheme is adopted, a large area of condensation will inevitably occur on the inner surface of the top of the glass cone. If double-layer glass is used, most of the air temperature can be at 14 $°C$ or above, and even the edge area of the most unfavorable cone top can reach an air temperature of 13 $°C$. On the other hand, the temperature on the inner surface of the conical glass has also increased to a certain extent. According to the difference calculation, the temperature on the inner surface of the conical side can be around 6.3 $°C$, slightly higher than the dew point temperature of the air. The inner surface temperature at the top of the cone is 4.4 6.3 $°C$, and the surface area below the dew point temperature of 6 $°C$ accounts for about 60% of the total top area. This means that a considerable portion of the inner surface at the top will still experience condensation. According to the above analysis method, it is recommended that the heat transfer coefficient of the inverted atrium glass should not exceed 2.5W/(m^2 ° K).

4. Conclusion. In response to the current pursuit of aesthetic and eye-catching benefits in the development process of commercial buildings, the large-scale adoption of transparent enclosure structures has led to difficulties in meeting indoor thermal comfort and high operating costs. For a large commercial building, analysis and calculation were conducted from several aspects, including optimizing the performance of glass curtain wall enclosure structures, designing anti condensation measures for glass atriums, and designing natural ventilation during the transition season, thus, the energy-saving design of the enclosure structure of the large commercial building and the improvement of indoor environmental quality were achieved. The author has made beneficial explorations on how to build energy-efficient commercial buildings in bustling urban centers, and how to use passive means (such as natural ventilation, natural lighting, etc.) as much as possible to improve indoor environmental quality, which has reference significance for other similar buildings.

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