Preliminary Exploration of Energy Saving Office Building Design in Hot Summer and Cold Winter Area

Naiwen Zhang
School of Civil Engineering and Architecture, Wuhan University of Technology, Wuhan, Hubei, 430070, China
Email: naiwenzhang@whut.edu.cn

Abstract. With the continuous development and progress of society, office building has become an indispensable part of it, but at the same time, a large number of modern offices are in a state of high energy consumption and environmental protection. Therefore, environmental protection, energy saving and comfortable office space has become the demand of modern people for the workplace. This paper shows the design process of an office building at the intersection of Wuhan pedestrian street and main road, analyzes the architectural design from the perspectives of building land, building shape and building energy saving, and carries out optical design and acoustic design for the building to achieve the effect of building energy saving.

1. Introduction
At present, there are many papers on energy-saving office buildings in China, and many senior scholars have also explored this issue. Through the design practice and research of domestic office buildings, this paper puts forward the new design concept of green office buildings and analyzes how to realize energy-saving design in China. For later research and learning have a certain impact [1].

Under the current situation in our country, it is very difficult to realize and popularize the concept of energy saving in office building design. In order to maximize economic benefits, it is unrealistic to achieve energy conservation and environmental protection at the same time, and it is difficult to change the status quo in terms of policy control [2]. Therefore, in the design level, energy conservation and environmental protection is also a kind of exploration to solve the problem.

2. Preliminary Investigation of Architectural Design
The design site is located in Wuhan City, Hubei Province. Wuhan city is located in the central part of China, belonging to the typical subtropical monsoon humid climate, and the wind direction has obvious changes in winter and summer. The dominant wind direction is north wind and northeast wind in winter, and southwest wind and south wind are dominant wind direction in summer. In addition to the influence of the terrain, there are many breezes and still winds, and the climate is relatively muggy and humid. According to China's thermal division, Wuhan belongs to hot summer and cold winter area. According to the design requirements of "code for thermal design of civil buildings", "design standard for energy efficiency of residential buildings in hot summer and cold winter zone" and "code for design of office buildings", the design objective must meet the requirements of heat protection in summer and heat preservation in winter.

The south of the site is a pedestrian street with dense pedestrian flow, and the east side is the urban trunk road. The sound insulation design should be considered in both directions. The park green space...
in the north and West is relatively quiet, which can be used for office design. There are no tall buildings around the base, so lighting only needs to consider its own design requirements.

3. Scheme Conception and Energy Saving Design

3.1. General Idea
Different building shapes will lead to different solar radiation areas in different directions. The design object is the office building, so the centralized composition is adopted. The energy consumption of the building increases with the increase of the shape coefficient. The smaller the shape coefficient is, the better the energy saving effect of the building is.

Considering the terrain characteristics of the area where the design target is located and the requirements of the design task, the rectangular shape of the building is selected. Because the building in the north-south orientation to get more solar radiation, so the summer ventilation design needs to pay more attention. Because the design of the site is north-south deep, and did not use the North-South layout, so it did not affect the building's normal lighting and ventilation requirements.

Reasonable building layout will bring great convenience in the aspects of light acoustics design and user use. The parking lot and main entrance should be set at the location convenient for traffic.

Considering the building shape, plane layout and the overall situation of the base, the design of the office building adopts the broken line shape, with a total of five floors, and the main entrance of pedestrian is arranged towards the main road and faces east.

3.2. General Layout Design
The premise of determining the location of a single building is to make necessary functional zoning of the general plan. The designed main functional areas are: building land, traffic distribution land, landscaping land. At the same time, some planning requirements need to be met. According to "code for calculation of building area of building engineering", we planned documents of relevant local departments. In the general layout design of buildings, it is necessary to consider the influence of building plot ratio and greening rate on personnel activities and project cost.

Building land: the building conforms to the red line shape of the base and forms a folding line. There are 5 floors in total. Set up the main entrance, secondary entrance and other road access.

Green land: green land mainly includes trees, lawn and other planting areas. By planting trees can form a natural barrier, play a role in greening and wind guide.

3.3. Architectural Function Design
The streamline of the building should be concise and clear. The rooms that need a lot of light in the office should be arranged in the south direction, so as to make full use of the sunlight to achieve the purpose of passive energy saving. The office building has five floors with an average height of 3.6 meters. The area of the first floor is 620 square meters, the area of the second floor is 1080 square meters, the area of the third floor is 650 square meters, the area of the fourth floor is 650 square meters, the area of the fifth floor is 650 square meters, and the total construction area is 3650 square meters, meeting the design requirements of 3500 square meters (± 5%).

3.4. Acousto Optic Calculation and Optimization of Building Energy Saving

3.4.1. Computer Simulation of Climate Environment. After the preliminary idea of building energy conservation, combined with the results of building lighting simulation, the building environment is further optimized. According to the simulation results as shown in figure 1, the building can meet the lighting requirements and the indoor natural light is sufficient to meet the passive energy-saving design requirements.
3.4.2. Analysis and Calculation of Building Light Environment. 1) Lighting analysis of buildings
In order to obtain a good lighting environment and save energy, various kinds of daylighting openings (Windows) are arranged on the building envelope (wall and roof). According to its location, daylighting can be divided into side window and skylight [3]. According to the requirements of architectural function and visual work, the reasonable lighting mode is selected. The window opening mode of the office building is selected as side window. Because of its simple structure, convenient layout, low cost, and clear direction of light, it is conducive to form shadows. It is especially suitable for viewing vertical objects, and can see the external scenery and expand the field of vision through it, so it is widely used. In this design, comprehensive consideration of architectural modeling and lighting design, in the office design of large French windows, the use of directional shading glass [4].

2) Lighting calculation
The area proportion of main functional rooms in public buildings meeting the requirements of current national standard "standard for daylighting design of buildings" (GB 50033) shall not be less than 60%.

The design of building facade shall meet the following requirements:
It should not produce light pollution to the surrounding environment, and should not use mirror glass or polished metal plate and other materials; the design of glass curtain wall should meet the requirements of relevant government regulations, and the visible light reflection ratio of glass curtain wall should not be greater than 0.2.

According to $E_{av} = N \cdot \Phi \cdot U \cdot K / A$, the average illuminance was calculated.
Where
$N$ --the number of light sources
$\Phi$ -- luminous flux of lamp source, lm
$U$ -- utilization coefficient, generally taken as 0.6
$K$ -- lamp maintenance coefficient, generally determined by the environmental pollution, can be taken as 0.8 for cleaner areas, 0.7 for general places, and 0.6 for heavily polluted areas.
$A$ -- working face area, $m^2$
LPD = $\sum P/A$
Where, LPD -- power density value, unit: W / $m^2$;

**Figure 1.** Analysis of building sunshine and climate.
$\Sigma P$ -- the sum of the input power of the total lamps in the place, including those of the lamp tube itself and its accessory equipment (ballast).

The calculation is as follows:

- Small office: $E_{av} = 21000 \times 0.6 \times 0.7 / 5.0 \times 5.0 = 352 \text{ (lx)} > 300 \text{ (lx)}$
- Large conference room: $E_{av} = 12 \times 840 + 3 \times 21000 \times 0.6 \times 0.7 / 8.4 \times 12.0 = 304.5 \text{ (lx)} > 300 \text{ (lx)}$
- Activity room: $E_{av} = 12 \times 840 + 6 \times 21000 \times 0.6 \times 0.7 / 9.0 \times 10.0 = 635 \text{ (lx)} > 600 \text{ (lx)}$
- Toilet: $E_{av} = 10 \times 840 \times 0.6 \times 0.7 / 5.0 \times 6.0 = 117.6 \text{ (lx)} > 100 \text{ (lx)}$

Selection and arrangement of lamps and lanterns

Due to the need to reduce the reflected light, the dark semi direct lamps and lanterns are used in the form of partition lighting [5]. Key points of layout design: the adjacent surface of visual operation and the decoration performance in the room should be made of lusterless decorative materials.

3.4.3. Analysis of Building Acoustic Environment

1) Sound insulation design

In the design of office buildings, it should be avoided to arrange offices and meeting rooms adjacent to rooms with obvious noise sources; rooms producing high noise (including equipment and activities) shall not be arranged in the upper (floor) of offices and meeting rooms. When the office is arranged on both sides of the corridor, the doors relative to the room should be staggered [6].

For offices and meeting rooms facing urban trunk roads and other outdoor high noise environments, the building envelope with corresponding sound insulation performance (including walls, windows, doors and other components) should be designed according to the outdoor environmental noise status and the determined allowable noise level [7]. The partition wall between adjacent offices shall be extended above the ceiling height and connected with the load-bearing floor without gaps.

2) The sound insulation and anti-noise design of the scheme

Taking the East office as an example, the overall office adopts light sound insulation wall: length × width × height = 18 × 10 × 3.6 m. Considering the lighting of the office, fixed sound insulation windows are installed on both sides of the corridor. The window is 1m high from the ground, and the size is l × w = 3.5 × 1.1 m. The sound insulation door L × H = 1.0 × 2.40 M is installed on the other two sides. The insertion loss TL of sound insulation room / door / window is 25 ~ 30 dB (A) [8].

- Room structure: the exterior wall is painted with white emulsion paint + low frequency sound insulation module + 13 mm broadband damping sound insulation board + steel structure is filled with 50 mm polyester fiber cotton + the keel is lined with 9% board + polyester fiber board. The selected materials are green and environment-friendly, formaldehyde free, harmless to human body, and the fire rating is B1.

3.4.4. Construction of Sound Absorption and Sound Insulation Technology for Building Envelope

- Roofing
  - Roof type (from top to bottom): Pebble (50 mm) + polystyrene board (100.00 mm) + waterproofing membrane, polyurethane (3.00 mm) + cement cinder (70 mm) + cement mortar (20.00 mm) + reinforced concrete (10.00 mm) + cement mortar (10.00 mm).
  - Exterior wall
  - External wall type (from outside to inside): facing layer (10.00 mm) + adhesive layer (5.00 mm) + welded steel wire grid (8.00 mm) + cement mortar (10.00 mm) + hollow vitrified micro bead thermal insulation mortar (30.00 mm) + cement mortar (10.00 mm) + reinforced concrete (200.00 mm), solar radiation absorption coefficient is 0.50.
- Floor
  - Floor construction type: oak, maple (horizontal wood grain) (12.00 mm) + general air layer (vertical air layer) (8.00 mm) + reinforced concrete (120.00 mm) + cement mortar (20.00 mm).
- Window
  - This design uses Low-E insulating glass, so SW = SC chooses sunshade Low-E insulating glass with better shading effect. Its glass type is sunshade Low-E + 9 air + 6 transparent, its shading coefficient is 0.41, heat transfer coefficient is 1.83, so SW = 0.41.
4. Achievement Display
After the relevant technical analysis and key points analysis, the author designs the scheme and presents it as technical drawings. The final effect is shown in figure 2.

4.1. Design Description
The multi-storey comprehensive office building in Wuhan is located at the intersection of Wuhan pedestrian street and main road. The pedestrian flow is relatively dense, and the pedestrian and vehicle flow on the main road is relatively dense. The park green space is in the north and west of the base, so the environment is relatively quiet. The building conforms to the red line shape of the base and forms a folding line. There are 5 floors in total. At the beginning of the scheme design of Wuhan multi-storey comprehensive office building, the actual factors such as climate, wind direction and sunshine in Wuhan area are fully considered, and the planning and layout of building energy-saving design, architectural acoustics and optical design are combined to contact the surrounding environment of the base. The technical drawings are shown in figure 3.

Technical and economic indicators
Total floor area: 3650 square meters
Total land area: 2686 square meters
Plot ratio: 1.35
Greening rate: 42%
Building density: 0.32

Figure 2. effect picture.

Figure 3. Technical drawings.
5. Epilogue
Building energy conservation has become a global trend, which is conducive to the sustainable development of all walks of life, such as architecture. As a contemporary "social center" building, office building should play a leading role in other architectural design to join the energy-saving team as soon as possible. The proposed design of energy-saving office building in Wuhan is a preliminary exploration of green building design in hot summer and cold winter area. It uses green building design concept to design commercial office building, optimizes office building through preliminary design concept, sound and light calculation and other steps, so as to reduce energy consumption of office building and provide people with a more environmentally friendly and comfortable office environment.

References
[1] Zhang X J 2020 Green building design strategy analysis of commercial office building Construction Materials & Decoration 6 102–103.
[2] Simplice I N T, Shyama P C and Thomas O O 2019 Intelligent Energy Management Strategy for Automated Office Buildings Energies 12(22)
[3] Sun H J 2019 Analysis of building ecological energy saving design concept of office building Intelligent City 15 146–147.
[4] Yang S S and Guan R M 2008 The situation analysis of eco-office building Fujian Architecture & Construction 9 36–37+42.
[5] Wang J 2019 Application of green energy-saving technology in B3 office building Construction Science and Technology 18 104–106.
[6] Jiang C Y 2017 Discussion on the key points of green high-rise office building design Architectural Practice 12 p58.
[7] Wagiman K R and Abdullah M N 2018 Lighting system design according to different standards in office building: A technical and economic evaluations Journal of Physics: Conference Series 1049(1).
[8] Killian M and Kozek M 2018 Implementation of cooperative Fuzzy model predictive control for an energy-efficient office building Energy and Buildings 158 1404-1416.