Comprehensive Application Analysis of the Building Shading System

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Abstract: In recent years, because people's awareness of building energy saving has been gradually enhanced, the building shading system has been paid attention by designers. Compared with the ordinary building shading system, the intelligently-controlled building shading system can better balance the relationship between shading and lighting, reducing the energy consumption of the building lighting and air conditioning. Therefore, intelligently-controlled building shading system will be more widely used. Different building shading systems have different effects. A reasonable building shading system should be selected according to the type of building and personnel requirements.

1. Introduction
With the development of building energy conservation, the building shading system plays an increasingly important role. In particular, the wide use of glass curtain wall not only brings a bright coat to the buildings, but also beautifies the view of streets. Nowadays the glass curtain wall has become a popular element of the large public buildings. But at the same time, the glass curtain wall also increases the building energy consumption, so people put forward the stricter requirements about energy saving efficiency of the building shading system.

Solar full spectral radiation is the key factor for people to feel comfortable for a long time. The exterior window can complete the natural day-lighting of indoor room, and can let people see the natural scenery which satisfy the psychological needs of communications between the indoor personnel and the outdoor scenery. It is an important way for people to improve working efficiency and physical and mental healthy. Therefore, the exterior window of buildings must exist and can not be canceled. So the improvement of building shading system of exterior window is very important to building energy saving. Intelligent control is an important developing direction to optimize the building shading system.

2. Classification and characteristics of the building shading system
The energy of solar radiation is mainly concentrated in the wavelength range of 0.2 ~ 2 μm. The visible-light and near-infrared energy takes a large proportion, as shown in Figure 1. The solar radiation energy of these two sections must be reduced in order to achieve energy saving of the air conditioning in summer.
The building shading system can be divided into external shading of buildings, interior shading of buildings and building glass-walled shading. External sun shading refers to a shading device installed outside the building enclosure, it also includes the plant shading which means people use some plants to shelter from the day-light. The interior shading of the building is a shading device installed inside the building envelope, the most common method is curtain. The building glass-walled shading refers to the building enclosure directly using shading energy-saving glass. Conventional energy-saving glass refers to shading energy-saving glass, mainly including heat-absorb glass, heat-reflection glass, low impassivity glass. Performance comparison of the building shading system see Table 1.

Table 1. Performance comparison of the building shading system.

| Type                        | Method                  | Performance       | building outside view | Indoor daylighting and visual sense | Shading means          | Usage                                      |
|-----------------------------|-------------------------|-------------------|-----------------------|-------------------------------------|------------------------|--------------------------------------------|
| Plant shading               | No change in summer     | No influence      |                       | Great influence in summer            |                        |                                            |
| Building glass-walled shading | Fixed throughout the year | No influence     |                       | Have influence                      |                        |                                            |
| Fixed component shading     | Fixed throughout the year | Have some influence |                       | Have influence                      | Directly prevent the heat of solar radiation enter room. The shading result and energy saving is the best. | Limited by the requirements of the building outside view |
| Aluminum alloy louver shading | Electric intelligent control | Great influence |                       | Have influence                      |                        |                                            |
| Aluminum alloy grid shading | Fixed throughout the year | Great influence  |                       | Have influence                      |                        |                                            |
| Rolling shade               | Only open and close      | Great influence   |                       | Have influence                      |                        |                                            |
| Fabric tarpaulin shading    | Only open and close      | Great influence   |                       | Have influence                      |                        |                                            |
Table 1 shows that because the shading performance of most building shading systems is fixed throughout the year, it is necessary to increase the lighting of indoor lamps in order to meet the indoor illumination. However, increasing the lighting of indoor lamps means the energy consumption of indoor lighting and electric equipment (lamps) will increase. If the building shading system can be intelligently controlled, people can adopt natural lighting as far as possible while ensuring the influence of building shading. This method can reduce power consumption of the lighting and energy consumption of air conditioning.

3. Intelligent control louver
The louver is a kind of common equipment to block the sunlight and control the indoor solar radiation. The intelligent control of the louver is to optimize the energy saving of the building shading system. Through real-time intelligent control, the inclination angle of the louver blade can reach the best angle of natural lighting as far as possible. While ensuring the natural light illuminance of the sunlight entering the room, the opening time of the indoor lighting lamp in the summer office can be reduced at the same time. Thus, the energy consumption of lighting and air conditioning is reduced to the maximum extent.

Based on the traditional louver, the intelligent louver adds the intelligent control system, which can realize the function of automatically opening and closing the louver and adjusting the angle of the louver blade according to the change of outdoor solar radiation and indoor illumination. Intelligent control components include a motor, an automatic controller, a temperature sensor and two photosensitive sensors. The resistance value of the photosensitive sensor and the temperature sensor reflects the change of illuminance which inside and outside the room and temperature of inside room. The automatic control device sends information to the motor to adjust the angle of the louver blade. The schematic diagram of intelligent louvers is shown in Figure 2.
4. Intelligent liquid crystal switchable glass
The intelligent liquid crystal switchable glass is a kind of shading system which can replace the curtain and louver. It is fully transparent when the power is on and not transparent when the power is off, and it also has the function of achieving different transmittance by regulating the electric current. As the exterior window or the glass curtain wall, intelligent liquid crystal switchable glass can play the role of shading in intelligent building, reducing indoor lighting energy consumption and air conditioning energy consumption. The intelligent liquid crystal switchable glass can also be used for the interior partition of large indoor space, and its working principle is shown in Figure 3 and Figure 4. When the switchable glass turns off the power supply, the liquid crystal molecules in the electrically controlled switchable glass will appear irregular dispersion state. When the switchable glass is electrified, the liquid crystal molecules in the glass are neatly arranged, and the light can freely pass through so that the dimmer glass becomes transparent instantly.

5. Reasonable selection of building shading system
People are always in favor of tall and bright windows. The windows of new buildings are became larger and larger, and the glass curtain wall building is more and more popular. But large windows will not conducive to building energy saving. Therefore, it is necessary to choose the reasonable building shading system carefully.
Table 2. Comparison of people's differences and needs in different buildings.

| Project                        | Office | House | Hotel | Shopping mall |
|--------------------------------|--------|-------|-------|---------------|
| Properties of the air conditioning | Working | Living | Leisure time | Leisure time |
| Architectural space            | Low floor height | Normal | Normal | Tall and big space |
| Activity space and area        | Small | Relatively bigger | Relatively bigger | Bigger |
| Active state air conditioning  | Working | Resting | Leisure | Normal |
| time at the same position      | longer | longer | shorter | More shorter |
| Mental state                   | Tension | Relaxed | Relaxed | Normal |
| Personnel clothing             | Formal | Informal | Leisure | Leisure |
| Illumination demand            | Stronger | Strong | Not strong | Not strong |
| Thermal demand                 | Strong | Strong | Strong | Not strong |
| Outdoor scenery watching demand| Strong | Stronger | No requirement | No requirement |

Table 2 shows that different types of buildings have different requirements for the shading system so that the choice of the building shading system should avoid blindness and abuse. At present, the main problems with the building shading systems include: ①The psychological demands of indoor personnel for natural lighting and visual view of the outside scenery are neglected. ②The need for lighting is neglected in different types of rooms. The excessive shading with office buildings will lead to the increase of energy consumption of indoor lighting and air conditioning operation. ③The influence of exterior shading system on the building outside view is neglect. ④The problem about durability and safety of the building exterior shading system is neglect. ⑤The problem about initial investment and economy of the building shading system need to analysis carefully.

Table 3. Applicability analysis of the building shading system.

| Type                  | Form                        | Applicable building type | Shortcomings                                      | Else                                                      |
|-----------------------|-----------------------------|--------------------------|---------------------------------------------------|-----------------------------------------------------------|
| Plant shading         | Building glass-walled shading | Indoor natural lighting may be insufficient in summer. | Tree growth cycle is longer.                     |                                                           |
| External shading of buildings | Fixed component shading Aluminum alloy louver shading Aluminum alloy grid shading Rolling | Low-height building | Building exterior facades have sunshade facilities, indoor room’s day-light and visual view are limited. | At the architectural design stage, the architect is required to intervene and draw them in the construction drawings. |
From Table 3 we can see that a comprehensive analysis of the technical, economic and energy efficiency should be carried out when choosing building shading systems. The problems need to pay attention including below: ① The matching applicability of the type of building and its using function. ② The degree of demand for indoor natural lighting by personnel. ③ The degree of demand for visual viewing through the windows by personnel. ④ The problem about balance between shading energy saving in summer and heating energy saving in other seasons (especially in winter). ⑤ The influence of the building outside view. ⑥ The construction difficulty and the safety problem. ⑦ The cost of operation and maintenance. ⑧ The problem of initial investment and economic benefit.

6. Summary
This paper introduces the classification and characteristics of building shading systems. The intelligently-controlled building shading system can not only play a role in shading, but also can better take into account the relationship between sunshade and indoor natural lighting, having a better energy saving effect. Therefore, the internalization of the shading system is one of the future development directions. When selecting the building shading system, the analysis of technical economic and energy-saving influences should be carried out to avoid using blindly.

Reference:
[1] Xiao Lin, Yu Wenhong, Wang Fulin. Research on the Integrated Optimization of Illumination Energy Consumption and Air-conditioning Energy Saving of Intelligent Blade[J]. The 2014 excellent undergraduate graduation Proceedings of Northern Polytechnic University.
[2] Xiao Lin, Wang Fulin, elegant Spring. Study on the influence of optimal Control of Intelligent Blade on Energy consumption of Air-conditioning and Lighting [J]. Smart Building 2015 (05): 48-50.
[3] Chen Zhan, Tang Guoan. A brief talk on Intelligent shading system in Intelligent Building[J]. Chinese and Foreign Architecture 2009 (07): 58-59.
[4] Jiang Yi, Huang Zhong. Sun shading and energy saving in buildings[J]. Building Energy Saving
[5] Laura Bellia, oncetta Marino, Francesco Minichiello, Alessia Pedace. An Overview on Solar Shading Systems for Buildings[J]. Energy Procedia, 2014, 62.

[6] Zhao Yongqian, Zhang Yaping, Xu Guangjian, Fang Lingmeng, Liu Jinzhu. Intelligent switchable glass device based on liquid crystal electro-optic influence[J]. Experimental Technology and Management (03): 101-104.