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INTEGRATED APPLICATION OF CADMIUM TELLURIDE THIN-FILM MODULES IN CURTAIN WALL ROOFS

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Abstract: As an important place for display and communication, the design of large exhibition halls must not only meet the requirements of aesthetics and functionality, but also be combined with its subsequent use and green construction. This paper aims to deepen the photovoltaic design of the skylight of large exhibition halls, considering its large area, ground-based structure and lighting projection area, and explore how to make full use of renewable energy such as light energy and heat energy while ensuring aesthetics and functionality. A set of perfect design and construction methods are proposed, and verified and applied through actual cases.
Keywords: Cadmium telluride film; Large exhibition hall; Curtain wall design; Curtain wall roof; Key technology; Application case

INTRODUCTION

With the increasing global climate change, it is particularly important to promote green planning, green design, green investment, green construction, green production, green circulation, green life and green consumption in an all-round and full-process manner. In the context of the intensification of global climate change and the depletion of renewable energy, how to make development and construction based on the efficient use of resources, strict protection of the ecological environment and effective control of greenhouse gas emissions, and how to use technical means to promote green construction and green construction to a new level. To achieve the above goals, we explore the potential of building construction under the premise of always adhering to the primary premise of green construction, and through architectural design methods, we start from the effective use of energy, while ensuring its architectural aesthetics and functionality, and maximize the use of clean, safe, inexhaustible and inexhaustible energy. Ensure the implementation of green buildings to ensure the realization of carbon peak and carbon neutrality goals, and promote my country's green development to a new level [1].
This paper aims to deepen the design and use of skylights in large exhibition halls, deepen the photovoltaic design of skylights, and explore how to make full use of light energy and heat energy while ensuring aesthetics and functionality requirements, so as to increase the proportion of green energy and renewable energy [2]. According to the large-scale and ground-type design characteristics of the exhibition hall, through the analysis and research of photovoltaic materials, structural design, construction technology and other aspects, a set of perfect design and construction methods is proposed to provide reference and guidance for the integrated design of renewable energy and curtain wall structure of large exhibition halls. At the same time, it will further advance the development of photovoltaic building integration [3].

1 PROJECT OVERVIEW

The first phase of the Hangzhou Convention and Exhibition Center is a large-scale comprehensive exhibition hall project, mainly composed of standard exhibition halls, conference centers, grandstand exhibition halls, and central corridor service spaces; the total construction area of the project is 1.22 million square meters, of which the first phase project has a total of 8 exhibition halls and central corridors, with a construction area of 64.32 square meters, an area of 215,700 square meters, a single-story above ground (partial double-story), a top design elevation of 42.36 meters, a curtain wall horizontal span of about 184 meters, a cornice aluminum plate system of 12,000 square meters, a cantilever structure height of 25.8 meters to 42.36 meters, a cantilever arc of 18 to 40 degrees, and a photovoltaic curtain wall area of 7841 square meters. The total installed capacity of photovoltaic power generation is 771.88kWp, with 3,356 pieces of 30% light-transmitting cadmium telluride thin-film photovoltaic glass and about 326 pieces of special-shaped non-power-generating glass installed. After the completion of the project, the annual power generation is expected to reach 700,000 kWh, which will become the "Linkong cover, Hangzhou showcase, and a new highland for national exhibition business". Large-scale exhibition halls are the main supporting carriers for urban display and communication. Their green energy use and system are important components of the curtain wall system. Their performance and structure requirements are higher, and various structural parameters need to be considered comprehensively during the design process.

2 KEY TECHNOLOGY SELECTION AND INTEGRATION

Under the dual carbon goals, renewable energy is used in a variety of ways. In order to promote the sustainable use of renewable energy, the implementation of photovoltaic facilities has been accelerated. In order to achieve the dual carbon goals as soon as possible, green energy building integrated facilities have emerged. In view of the large-scale exhibition hall projects with large land occupation and ground-type design characteristics, the photovoltaic building integrated engineering exhibition continues to move forward, and it is particularly important to select high-efficiency and high-utilization regeneration systems.

2.1 Traditional Monocrystalline Silicon Solar Cell System

Currently, crystalline silicon materials (including polycrystalline silicon and monocrystalline silicon) are the main photovoltaic materials, with a market share of more than 90%, and will continue to be the mainstream material for solar cells for a considerable period of time in the future.

Using high-purity monocrystalline silicon rods as raw materials, monocrystalline solar cells have high photoelectric conversion efficiency (conversion rate is between 15.4%-26.3%), and stand out in photovoltaic applications.

The monocrystalline silicon solar cell panel is fixed on an aluminum plate with a copper tube on the back to form a system. The team compared the photovoltaic thermal system with the photovoltaic solar thermal deposition system. The analysis results show that the overall energy efficiency of the photovoltaic thermal system is close to the solar thermal deposition system, and photovoltaic thermal has a higher firefighting efficiency than the other two systems. In order to simulate the various parameters of the calculation system, the simulation results show that the electrical performance, thermal efficiency, total conversion efficiency and thermal utilization efficiency of the system are 10.01%, 17.18%, 45.00% and 10.75% respectively.

2.2 Polycrystalline Silicon Solar Cell System

Polycrystalline silicon solar panels are usually made of discarded monocrystalline silicon tailings or metallurgical silicon materials, and their cost is lower than that of monocrystalline silicon. Monocrystalline silicon solar panels are developed on the basis of solar panels, of which the photovoltaic industry accounts for 70%. The photoelectric conversion efficiency of polycrystalline silicon solar cells is usually lower than that of photovoltaics. The conversion efficiency of monocrystalline silicon solar panels with the highest speed is about 20.89%. The temperature coefficient of crystalline silicon solar cells is relatively high; the photoelectric conversion efficiency of crystalline silicon solar cells decreases more significantly with the increase of their own temperature; how to effectively use the heat absorption layer to remove the heat of crystalline silicon solar panels in time; the production cost of crystalline silicon solar cells is high, and their low-light performance is poor. Therefore, the performance of crystalline silicon solar cells needs to be further improved.

2.3 Cadmium Telluride Thin Film Curtain Wall System

Compared with other solar cells, the structure of cadmium telluride thin film solar cells is relatively simple, usually composed of five layers, namely glass substrate, transparent conductive oxide layer, cadmium sulfide (CdS) window layer, cadmium telluride absorption layer, back contact layer and back electrode.

Cadmium telluride is a direct gap semiconductor, its gap width is very well matched with the solar spectrum, and its gap width can work normally at high ambient temperature, with good radiation resistance. In addition, cadmium telluride solar cells are composed of polycrystalline thin films, and the preparation process is relatively simple. Therefore, the application of cadmium telluride solar cells is very promising, especially for high-altitude and desert power plants, outer space and deep space energy, and as compressed batteries. Electrical performance parameters can be seen in Table 1, and Mechanical parameters can be seen in Table 2.

Table 1 Electrical Performance Parameters

model	JC-RTN			
Pattern form	Royal blue	Royal blue	Yellow	Green
Power	65Wp	85Wp	85Wp	85Wp
Power tolerance	±5			
Short circuit current	0.71A	1.13A	1.08A	1.06A
Open circuit voltage	117.2V	118.4V	118V	117.2V
Peak power current	0.52A	0.97A	0.91A	0.92A
Peak power voltage	72V	97.1V	94.7V	90.1V

Table 2 Mechanical Parameters

Component dimensions	1200×600×9.34mm	Battery type	Cadmium telluride thin film
Weight	16.8kg	area	0.72m^2
Connection box	Back or side connection, cable2.5mm^2，650±10mm		
Connector	MC4 or MC4 compatible		
Structure	3.2mmCdTe+0.38mmPVB+0.76mmPVB+5mm		

3 INTEGRATED APPLICATION OF CADMIUM TELLURIDE CURTAIN WALL AND ROOF IN LARGE EXHIBITION HALLS

3.1 Key Scientific and Technological Points Taking the Photovoltaic Roof of Hangzhou Convention and Exhibition Center as an Example

In the construction of the photovoltaic curtain wall project of the skylight roof, cadmium telluride thin film modules were applied to the construction of the integrated photovoltaic project of the building for the first time. Under the premise of ensuring the primary requirements of the structural transmittance, cadmium telluride light-transmitting modules with a transmittance of 30% were used to generate more than 700,000 kWh of electricity per year, which is equivalent to the lighting power consumption of the basement and ground offices of Hangzhou Convention and Exhibition Center, and equivalent to planting more than 30,000 trees next to the building.

In the photovoltaic integration construction, cadmium telluride photovoltaic modules with a single capacity of 320Wp were used, and 3,356 single 320Wp modules were installed. The total photovoltaic capacity is 771.88kWp. The photovoltaic module layout adopts the roof flat laying method, with 6/7 photovoltaic modules as a group, and 3 groups are equipped with a set of photovoltaic return kits, and 1*6mm^2 photovoltaic lines are used to lead to the inverter in the distribution room through the cable trough box. The project is equipped with 10 inverters, and every 5 inverters are connected to a low-voltage cabinet grid-connected cabinet. This project uses 2 400V low-voltage grid-connected cabinets, and uses 2 transformers for power consumption. The power generation form is self-generated and self-used, and the surplus power is connected to the grid. While meeting the light transmission requirements of the skylight, combined with power generation, the subsequent use efficiency is improved, and the use of green energy for environmental protection is promoted. At the same time, the use of assembly components saves a lot of maintenance costs compared with traditional processes, reduces material waste and environmental pollution, and is in line with the development trend of green and low-carbon buildings in my country.

3.2 Main Construction and Installation Technical Measures

The construction method of cadmium telluride thin-film photovoltaic roof installation mainly includes nine parts: measurement and re-measurement and photovoltaic component installation, system debugging, array line construction, junction box installation, photovoltaic inverter installation, distribution panel cabinet installation, cable laying, lightning protection and grounding construction, and trial operation.

3.2.1 Measurement and component installation

1. Construction measurement and layout

The basis for construction measurement includes plan layout drawings, construction drawings, and positioning control points of the construction site. The main contents of construction measurement include checking coordinate points, laying out points based on coordinate points, and related openings.

2. Photovoltaic bracket and component installation plan

The photovoltaic components are fixed to the original roof frame with bolts; the flatness of the original roof frame and the deflection of the supporting beam are re-measured; if it exceeds the specified range, the corresponding construction party needs to make rectifications; re-measure the reserved holes, and compare the position of the pressing block and the size of the components and small frames to see if they meet the installation requirements.

4) Photovoltaic component installation

During transportation and storage, the components should be handled with care, without strong impact and vibration, and should not be placed horizontally and heavily. Prevent hidden cracks in the battery and affect operating efficiency. The components should be installed from bottom to top, one by one, and must be handled with care during the installation process to avoid damaging the surface of the components. The components must be installed horizontally and vertically, and the spacing between the components in the same square array should be consistent; pay attention to the direction of the component's junction box. The connection between the components and the bracket system can be installed using the mounting holes on the frame, clamps or embedded systems. Just like Figure 1-4, the installation of components must be carried out in accordance with the following examples and suggestions.

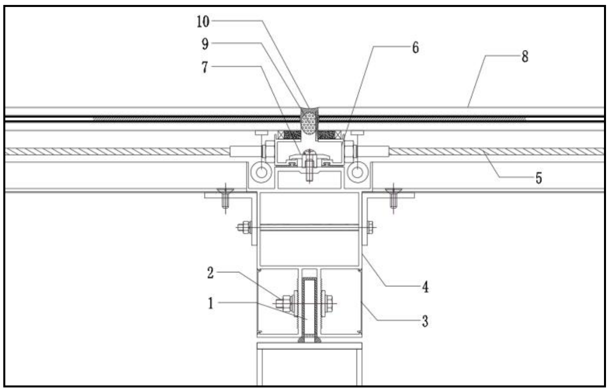

Figure 1 Schematic Diagram of Photovoltaic Module Installation

1-Steel plate; 2-Stainless steel bolts; 3-Aluminum alloy buckle cover; 4-Aluminum alloy main keel; 5-Stainless steel anti-fall rope; 6-Aluminum alloy auxiliary frame; 7-Aluminum alloy block; 8-High-transmittance photovoltaic glass (8mm ultra-white tempered glass + 1.52mmPVB + 3.2mm cadmium telluride power generation glass + 1.52mmPVB + 8mm ultra-white tempered glass); 9-Aluminum alloy support strip; 10-Silicone sealant.

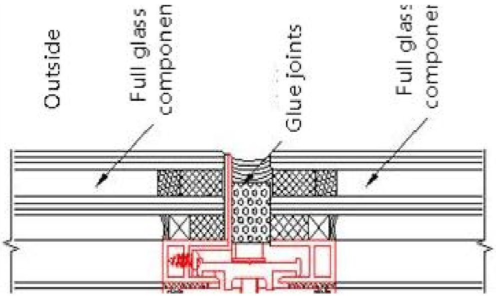

Figure 2 Schematic Diagram of Photovoltaic Module Installation

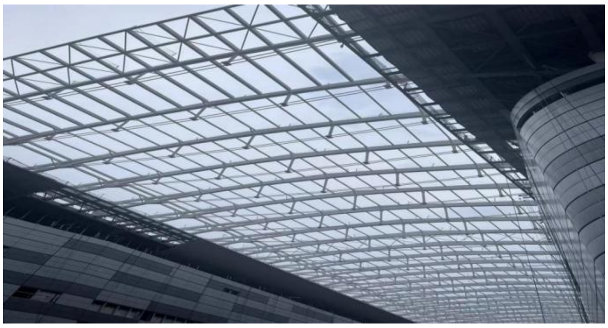

Figure 3 Roof Truss Span Structure Diagram

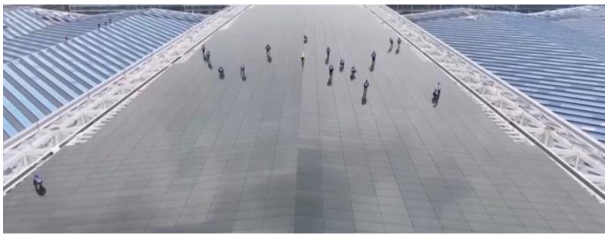

Figure 4 Photovoltaic Roof Installation Effect Diagram

4 PHOTOVOLTAIC CURTAIN WALL ROOF QUALITY CONTROL

The use of this process is closely related to the quality control during the use of the process. During the construction and use, attention should be paid to the process quality and comprehensive quality problems should be dealt with.

A quality reward and punishment system should be established. According to the implementation of the system, everyone should clarify their respective quality responsibilities. Organize construction personnel to study the "Specifications", "Verification Standards", relevant technical documents and materials of the manufacturer, instructions and design requirements of the design institute, so that construction personnel can clarify the quality standards, master the installation and commissioning processes, and ensure the installation quality.

Before the project construction, the engineering quantity should be counted first, and the progress of the project should be arranged reasonably. Construction personnel must strictly carry out construction according to the construction organization design and the contents of quality, technology and safety disclosure, and do a good job of recording various original data.

When the bolt connection parts and bolt hole positions are inconsistent, fire welding shall not be used for cutting, and only re-drilling and adjustment can be made. Welding materials should be selected according to relevant regulations, and the welding materials used should have a supplier's warranty.

When handling equipment defects, we should take the initiative to work with the technical personnel and supervisors of the relevant parties to study and formulate solutions suitable for on-site construction. Carefully inspect and record all kinds of equipment defects and unqualified products, and handle them according to the requirements of the specifications.

5 CONCLUSION AND PROSPECT

Through the research on the integrated application of cadmium telluride thin film modules in curtain wall roofs based on the first phase of the Hangzhou Conference Center project in Hangzhou, the following conclusions can be drawn: With the improvement of building energy-saving requirements, new building energy-saving materials are also developing continuously. In order to significantly reduce the energy consumption of buildings, traditional photovoltaic roofing materials are mostly metal roofing + photovoltaic panel structures, which can no longer meet the requirements of large exhibition halls for energy saving, light transmission and beauty. The new technology of building and energy-saving integration has become an important direction for the development of green and low-carbon building energy-saving systems, and the technological development from energy saving to green power generation has become the next journey that the construction industry needs to move forward. Reasonable analysis of the application of each node, comprehensive economic considerations, and implementation after expert demonstration, the construction process is efficient and reliable, and possible problems are anticipated in advance and solved through technical means, saving construction costs and accelerating construction progress. At the same time, it creates favorable conditions for the integrated construction of photovoltaic buildings and has broad application prospects.

In order to implement the new technology of building and energy-saving integration, the following three technical difficulties need to be solved: first, to ensure the original light transmittance requirements of the skylight; second, to ensure the overall quality and durability of the curtain wall roof; third, to improve the green energy flow of large exhibition halls and promote the low-carbon development of green buildings.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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