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Energy-Saving Construction Technologies and Operation and Maintenance Control of Ultra-Low Energy Building Based on Intelligent Control

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Abstract:

In recent years, the ultra-low energy building technology has developed rapidly. Various provinces and cities have provided relevant policy support, and numerous technical index documents and normative are constantly revised and updated as required. Technological innovation has been made in ultra-low energy building renewal, design and manufacture of new materials and intelligent operation and maintenance to continuously promote the development of the industry. This paper aims to summarize the general technical measures and construction technology for the conservation of ultra-low energy building and put forward the technical scheme of intelligent control and intelligent operation and maintenance to provide technical support for the development of building energy conservation technology.

***Keywords**: Ultra-low energy building, Energy saving technology, Construction technology, Intelligent operation and maintenance, Environmental protection.*

I. DEVELOPMENT OF ULTRA-LOW ENERGY BUILDINGS

To cope with global warming, energy consumption and environmental pollution, energy conservation and emission reduction have become a worldwide issue. Especially, the construction industry, as one of the main sources of energy consumption, accounts for about one third of the world energy consumption. With the implementation of the national energy-saving and emission-reduction strategy, the construction industry has accelerated technological innovation, quickly completed industrial upgrading and transformation, upgraded energy-saving methods of new buildings, formulated a series of policies, measures and development plans, actively built ultra-low energy building demonstration projects, so as to fully play the leading role in building efficiency improvement. At the same time, relevant national documents clearly require that we should adhere to the new green development concept, actively promote scientific and technological innovation and the development of ultra-low energy buildings, continuously improve the building quality, adhere to the development concept of low carbon, energy saving and high efficiency, and meet the people's demand for building comfort and health.

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II. ANALYSIS OF GENERAL TECHNICAL MEASURES FOR ULTRA-LOW ENERGY BUILDINGS

At present, China has formulated a series of energy-saving measures and general construction practices in building energy-saving design to ensure the construction of ultra-low energy buildings. For example, external wall thermal insulation system, door and window system, roof design and heatless bridge design, fresh air system have been applied to energy-saving buildings.

1) Adopting high-performance external thermal insulation system, selecting new composite wall materials and masonry materials with low heat storage and energy consumption, improving the thermal insulation performance of buildings, establishing composite external wall thermal insulation system, reasonably controlling the heat transfer coefficient of external walls and determining the thickness of thermal insulation layer.

2) Selecting external windows with high heat insulation and air tightness, installing energy-saving windows on the outside, and using high-performance window frames, thermal insulation glass and multi-cavity insulating glass.

3) Using roof thermal insulation design and materials with low thermal conductivity for construction, achieving thermal insulation through water storage and cooling measures such as overhead roof, roof greening and rainwater garden. The concept of sponge city provides a new idea for energy conservation and thermal insulation.

4) Design and construction of non-thermal bridges. Reducing heat loss by blocking the thermal bridges in the through-wall pipes, wall joint gaps, corner areas of external doors and windows, and by wrapping and filling the through-wall pipes, slab joints and overhanging components with heat preservation.

5) Through intelligent control technology, natural cold and heat sources, automatic control of frequency conversion operation and other energy-saving technologies, the new air heat recovery system adjusts the indoor temperature and humidity, reduces the energy consumption of air conditioning system operation, and alleviates the problems of high carbon dioxide concentration and difficult air circulation in high air tightness environment.

III. MAIN CONSTRUCTION TECHNOLOGIES OF ULTRA-LOW ENERGY BUILDINGS

1) For energy saving of doors and windows, economic and practical raw materials should be considered first. For example, in terms of the exterior windows of buildings, the wind pressure resistance

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should reach Grade 5, and the watertightness should reach Grade 3 and be greater than or equal to 250Pa. The airtightness should reach Grade 7 and be less than or equal to 1.5 cubic meters, and the air sound insulation should reach Grade 4 and be greater than or equal to 35dB. On the other hand, for the outer doors, its wind pressure resistance should be Grade 5 and greater than or equal to 3.0KPa, and its water tightness should be Grade 3 and greater than or equal to 250Pa. Its air tightness should be Grade 4 and less than or equal to 2.5 cubic meters, and its air sound insulation should be Grade 5 and greater than or equal to 25dB. In addition, the steel-aluminum double-layer hollow glass window with broken bridge should be used as outer windows, and the stainless steel glass doors should be used as outer doors. The wooden doors should be used as inner wall doors on the ground. The toughened glass partition door should be used in the shower room, and the steel-aluminum double-layer hollow glass window with broken bridge should be used as the inner window [1]. Safety glass should be applied on the first floor door and used as floor-to-ceiling window glass, and anti-collision marks should be set. Door and window joints and hardware fittings need to be selected in strict accordance with relevant national standards, specifications and total numbers. It is also necessary to communicate with manufacturers in advance to make it clear. Except for extremely special logo heights, a threshold of 100mm should be set, and its width should be consistent with the wall width.

2) Wall energy saving, which accounts for the highest proportion in the building, can be applied to the basic wall. The bearing reinforced concrete with a total thickness of 200mm can be used, and aerated concrete blocks are required, the strength of which cannot be lower than MU5.0. Ready-mixed special mortar is required for masonry, and the mortar mark cannot be lower than M5. Under the wall, it is necessary to set a 200mm C20 concrete retaining wall. Except for the reinforced concrete wall, the rest width should be consistent with that between the walls.

3) In terms of roof energy saving, solar energy is the most common green energy usually during the construction period. It can promote the implementation of sustainable development in all directions and protect the environment. The application of solar energy to the roof can make the sunlight contact and the buildings integrate with each other. During the construction period, with the help of solar energy, the original construction can be changed to a certain extent, and the consumption of construction raw materials can be handled. At the same time, more resources can be saved and green buildings can be built. The solar energy can not only meet the related needs of green buildings, but also improve the total life of buildings.

In addition, it is also necessary to pay attention to the requirements of environmental protection. With the continuous improvement of the economic level of Chinese citizens, the number of modern construction projects is on the rise, and at the same time, the building scale is constantly expanding. Under such circumstances, the consumption of resources is too large, which does not conform to the concept of green environmental protection development advocated by China at this stage. To meet the development

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requirements of green environmental protection and energy conservation under the background of the new era, each construction enterprise should appropriately reform and innovate its own concept of construction projects, taking all angles and links of construction projects as the starting point, so that construction projects can develop in the direction of reducing energy consumption and green environmental protection. When construction projects are under construction, among all kinds of energy consumption ratios, construction equipment and materials account for a large proportion. At the same time, these materials are the foundation of construction. Because of the large amount of raw materials used, the energy consumption will also increase, which will bring extremely serious impacts and threats to the local ecology and environment [2]. Therefore, it is necessary to incorporate the new concept of green energy conservation into construction projects, so as to purchase green construction raw materials to improve the utilization rate of raw materials. This way can not only reduce the energy consumption caused by construction, but also effectively prevent the local ecological environment from being polluted, which meets the requirements of China's green development. When purchasing green construction raw materials, relevant departments need to consider not only the actual economic situation of the construction enterprises themselves, but also the quality requirements and safety requirements in the process of building construction projects. On the basis of ensuring that the above conditions are effectively controlled, the goal of rational utilization of green and environmentally friendly raw materials for construction can be achieved [3]. In the construction of building projects, the application of green building materials can not only improve the overall efficiency and quality of the project construction to a certain extent, but also reduce the pollution impact in the construction process.

IV. TECHNICAL MEASURES FOR INTELLIGENT OPERATION AND MAINTENANCE OF ULTRA-LOW ENERGY BUILDINGS

General technical measures for energy saving of ultra-low energy buildings have been widely used, but there are still some misunderstandings in the process of building ultra-low energy buildings: such as emphasizing the importance of design but neglecting debugging, focusing on enclosure structure but ignoring the proportion of system operation, paying attention to the early construction but neglecting the operation, maintenance and management. As a result, the energy consumption found by the later monitoring is far higher than expected, and the energy saving effect is not satisfactory. Therefore, in the construction of ultra-low energy buildings, we should strengthen the later intelligent operation and maintenance to continue and realize the real low energy consumption.

In this paper, we carried out an investigation on the residential building project in Wanjing New Town, Huanghua City, Hebei Province, with a building area of about 8,000 square meters,. The original design scheme of the project was implemented in accordance with the limit requirements of local building energy-saving design standards. Now, the intelligent operation and maintenance system is used to optimize

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the original design scheme to verify the energy-saving effect of the system.

1) The load and energy consumption of ultra-low energy buildings is measured through intelligent system to get accurate data, and the operation rules are obtained through analyzing the data.

To further scientifically allocate the energy consumption of intelligent buildings, accurate data must be obtained through strict measurement and adjustment. The monitoring system is provided by an intelligent system integration company. By analyzing the enclosure structure, building layout, outdoor weather, indoor and outdoor temperature and humidity, building energy and other aspects, the load and energy consumption of the building are estimated. For example, heat flow meter is used to monitor the data of enclosure structure, the simulation calculation of building dynamic energy consumption is used to compare the building energy-saving effects under different envelope energy-saving schemes, the data of indoor environment comfort and other aspects are collected to obtain the operation data at different stages, the energy consumption data of air conditioners, elevators, and lighting fixtures are analyzed, and related data reports on overall energy consumption, monthly data, classified data, data correction and continuous optimization are formed, so as to obtain accurate energy consumption data of buildings.

2) According to the operation rules, effective technical measures and operation schemes are selected. The problems found are optimized and adjusted, and the continuous debugging of equipment and system is achieved.

① Adjusting the building layout. Through the analysis of data, it is found that some building units have relatively small windows and walls, compact layout and poor north-south permeability, which are not conducive to ventilation and easy to form heat accumulation. These problems can be optimized by adjusting the building layout, window-wall ratio, window opening position, etc. Strengthening indoor natural ventilation and reducing heat accumulation can achieve better natural ventilation and lighting effect. If the window opening position and plane layout have been formed, fine adjustment can be made without affecting the structure through fine decoration.

② Optimizing the external enclosure structure. The system can monitor the thermal performance and thermal performance of building composite thermal insulation wall, external window data including airtightness, sunshade, heat preservation and daylighting of aluminum composite windows are monitored, the absorption coefficient of building exterior coating is also used as monitoring data.

Huanghua City, Hebei Province is located in a cold area, so it is necessary to simulate and calculate the cooling and heating demand of buildings with different external wall heat transfer coefficient K values of residential building models. When the K value is reduced from $1.5w/(m^2\cdot k)$ to $0.5w/(m^2\cdot k)$, the energy

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saving effect is remarkable, when the k value is from 0.5w/(m^2·k) to 0.1w/(m^2·k), it tends to be stable, and the energy-saving effect is moderate, but the corresponding building heat demand is huge. So the K value in the northern cold region should be controlled at 0.5w/(m^2·k) to 0.1w/(m^2·k).

Because the roof of high-rise building accounts for a small proportion of envelope structure, its thermal performance has little influence on the overall energy consumption of high-rise building. In the design, the thermal insulation performance of the roof should be fully considered to reduce the influence on the thermal comfort of the top floor room.

To prevent condensation, in the process of design and construction, it is advisable to keep the average temperature of the inner surface of the outer window higher than 17℃, and the temperature of the inner surface (including the glass edge) should not be lower than 13℃. Through simulation, it is known that the K value of the outer window of Cangzhou City should be controlled in the range of 0.8w/(m^2·k) to 1.5w/(m^2·k). The solar heat gain coefficient SHGC should be ≥0.45 in winter and ≤0.30 in summer, which has a significant impact on energy saving.

In addition, the absorption coefficient of building exterior coating will also have an impact on building cooling demand. In this project, the original dark decorative materials with slightly higher absorption coefficient of exterior coating will be replaced by light decorative materials with low absorption coefficient, which will reduce the heat of solar radiation and achieve obvious energy saving effect.

③ Making full use of cold and heat sources. In the intelligent operation and maintenance control, to meet the comfort requirements, it is necessary to use the integrated intelligent home system to comprehensively and accurately control the household energy consumption demand, and actively control the high energy consumption equipment such as air conditioning, lighting, power supply and distribution, so as to realize self-regulation and economic operation. To achieve the best control of heat and cold sources in buildings, in the use of air conditioners, the supply air temperature is optimized, and the air temperature and humidity are adjusted. Besides, the supply air pressure is set scientifically and reasonably, and the fresh air quantity is controlled. The balanced flow of the cooling and heating system is controlled, automatically realizing the temperature control according to the user's set experience demand and obtaining a favorable and comfortable space environment. For example, the cooling and heating demand of buildings before and after adopting fresh air total heat recovery technology and fresh air sensible heat recovery technology is simulated and calculated. Through comparison, it is found that the total heat recovery technology is more energy-saving than sensible heat recovery technology, and its cooling load demand is reduced by about 5% in summer and 8% in winter. The fresh air total heat recovery technology can realize temperature exchange, humidity control and energy saving.

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④ Making full use of renewable energy. The system refers to Tianjin Eco-city project through the platform data. Solar photovoltaic power generation system is installed on the roof, which makes full use of solar energy resources and can block some direct sunlight. The system monitors the solar power generation, reserves the generated power and provides lighting for public areas.

3) Keeping up with the latest trend of intelligent operation and maintenance, accurately measuring and simulating the climate, air quality, comfort, residents' behavior habits and personalized needs during use, reducing uncertainty control, and using intelligent control technology to realize self-regulation and economic operation adjustment of high energy consumption equipment, avoid the waste in the operation process, and realize independent control and precise adjustment. Fundamentally speaking, we have collected and measured the data of resource usage in existing ultra-low energy buildings, analyzed the operation rules, and then continuously optimized and adjusted the platform by comparing and choosing the best scheme. With the help of cloud platform and big data technology, cloud analysis, cloud computing, cloud comparison and other technologies are used to feed back to the adaptive system to inform users how to conduct energy-saving control, so as to realize multi-feedback and continuous energy-saving control of intelligent buildings.

4) Intelligent analysis and early warning of equipment failure and equipment life. Intelligent operation and maintenance requires a large number of devices for data collection, measurement, feedback, monitoring, etc. The health and life of these devices directly affect the results of intelligent control and the efficiency of energy saving. Therefore, it is particularly important to integrate the intelligent equipment maintenance management system in the ultra-low energy building operation and maintenance system. Through the establishment of operation monitoring, data analysis, equipment health management, emergency management, maintenance and production, third-party unit management and other modules, accurate operation and maintenance can be achieved. For example, the equipment health management module can realize the health assessment, abnormal early warning and remaining life prediction of equipment and system components. At the same time, based on the actual operation and maintenance situation of big data platform and equipment, it can analyze and evaluate the on-site troubleshooting path of key operation faults, and guide the operation and maintenance personnel to carry out quick troubleshooting and emergency treatment, so as to maximize the efficiency of equipment and improve the efficiency and sustainability of energy saving [4]. The equipment management module is integrated to form an equipment status evaluation system and a standardized repair system, which can ensure better energy-saving effect and make energy-saving operation and maintenance more intelligent, sustainable, closed-loop and economical.

V. CONCLUSION

To sum up, universal technical measures and construction techniques have been developed in the construction of ultra-low energy buildings, which can promote the innovation of building component design, development of new materials and precise construction techniques, furthermore, the realization of intelligent technology and operation and maintenance undoubtedly provides a powerful boost. Intelligent control system can accurately control building energy consumption, reduce energy consumption demand, complement conventional energy-saving technical means, and meet the development requirements of current energy-saving technical measures. Its technical concept can effectively serve the strategic deployment of healthy China, create a comfortable and healthy living environment for the people and promote sustainable development, with immeasurable social benefits.

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REFERENCES

[1] Wang Xiaochen, Huo Da. Practical research on the construction of characteristic towns under the concept of integration of production and city and green development-taking Yanjiao High-tech Zone in Sanhe City as an example. Jiangxi Building Materials, 2021 (08): 230+233

[2] Wei Feng, Yang Xiaoran, Yu Bing, et al. Study on the design strategy of green cultural complex based on intensive theory — Taking the five halls and three centers project in Weihui City as an example. Architecture and Culture, 2020 (12): 152-154

[3] Liu Xiaolin. Discussion on design theory and engineering application of passive ultra-low energy building. Construction & Design for Engineering, 2019, (20): 25-26

[4] Ren Nannan, Sun Jingze. Research on energy-saving operation management strategy of ultra-low energy buildings in severe cold areas. Low-carbon World, 2017, (34): 209-210.