Research on Design of Low-energy Building in Cold Area

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Abstract — In today's world, energy has become a hot issue of growing concern. The major proportion of building energy consumption energy consumption in the whole society, so that building energy efficiency has become a pressing issue facing the world's construction industry. With the rapid development of national economy, accelerated urbanization process energy demand continues to increase. Long and cold winter weather in Chinese cold area, making the building energy consumption much higher than in other regions, according to the relevant building energy consumption survey, the region accounted for more than half of all energy consumption. Stadium building energy consumption is becoming large building energy consumption due to its huge building body mass and strict requirements for the indoor environment. Sustainable green building design increasingly of concern in today's world, in order to reduce the negative impact on the natural environment gymnasium and energy caused by low-energy stadium based architectural design is a practical design method, the stadium design should the respective architectural design elements to maximize the local climatic conditions adapt. Optimization of stadium construction in the indoor environment quality, but concerns the natural environment and sustainable development designed to promote a return to the design ideas of architectural design gymnasium hair, and achieve the purpose of building energy efficiency.

Keywords - Energy; Building Energy Consumption; Cold Area; Energy

I. INTRODUCTION

With the rapid development of national economy, office buildings show the trend of rapid development. Located in China's cold climate zone in major cities, the winter cold and summer heat dried hot. Ordinary office buildings generally consume a lot of energy to maintain proper mineral indoor environmental comfort, which resulted in building high operating costs and a series of environmental problems, there is a new era of progress requires low energy office building.

Since the 1990s, a growing consensus as enhance environmental awareness development in the world. Relations Contact architecture and environment closely, on the whole, the impact of the construction industry on energy consumption and global warming produced mainly by the following four ways: the production of building energy use; energy supplies transportation; housing construction and maintenance energy; building energy consumption for lighting, heating, cooling and ventilation.

China is currently in the peak of urban construction, promote the rapid development of urban construction materials industry, the rapid development of the manufacturing sector, resulting in energy consumption has accounted for 20% to 30% of China's total energy consumption of commodities. Where in the energy consumption of the building, and architectural lighting, heating, air conditioning and all types of energy consumption within buildings used to have occurred along the course of the building. In the construction of the full life Cycle energy consumption of building materials and construction process is generally only about 20% of the total energy consumption of energy, most of the energy consumption occurs during the building operation. Therefore, building energy consumption is building energy-saving tasks in the key.

Cold district gymnasium building energy consumption is huge, its low energy building design study is necessary. Since the stadium building features unique architecture and architectural form, making it low-energy building design and other building types has a great difference. This paper aims to study the impact analysis feature gymnasium cold regions of low-power design, lay the foundation for low-power design gymnasium cold areas, help to establish and improve the theoretical framework of building low-power design of the study, for the future of different regions, different buildings Research the type of low-power design provides a theoretical basis. Architectural features low power factors that influence the design of the stadium in cold area are: great technology, specialization and diversification match the spatial scale of the physical environment of indoor sports business model.

2004 China's building energy consumption is 170 million tons of standard coal plus 590 billion kWh of electricity, equivalent to the per capita energy consumption 937 kWh / year, accounting for 18.8% of the total social commodity energy consumption. Currently the major developed countries are building energy consumption accounts for about a third of total energy consumption (Fig. (1)).

Cold area long, cold winter weather makes the building energy consumption much higher than in other regions. In our country, Heilongjiang Province, the winter heating period of up to 180-210 days, the building energy consumption accounted for 37% of total energy consumption, of which the largest proportion of the heating
energy consumption. Therefore, based on the low-energy building design research it is necessary. At the same time, with advances in technology, human increasingly pursue the construction of large public buildings as economic prosperity, social progress flag. Architecture "strange new" eye-catching form at the same time, it began with the local natural climate disjointed, that contrary to the climate and environment of architectural form spawned a huge energy consumption, so that man will not merely pay a huge economic cost, at the same time increase the negative impact on the ecological environment.

In order to reduce the negative impact on the ecological environment gymnasium and energy caused by environmental adaptation of architectural design is based on low-energy gymnasium responsibilities of the architect's work. In the stadium design should enable the architectural design elements to maximize the adaptation with the local climatic conditions, to improve the gymnasium indoor environmental quality, attention to the environment and sustainable development design, design ideas to promote a return to the architectural design of the stadium development, and to achieve the purpose of energy efficiency in buildings.

II. RELATED CONCEPTS

Cold region: According to "civil design specifications" (GB 50176-93) the "Chinese building thermal design partitions" so-called cold area means Lilian the lowest average temperature is less than or equal to -10℃ areas, auxiliary index for the day the number of days the average temperature of less than or equal to 5℃ 145 days, must meet the design requirements for the winter insulation requirements, generally do not consider the summer heat. The main areas include Heilongjiang, Jilin whole territory, Liaoning, Inner Mongolia, Xinjiang, Tibet, northern Qinghai. Because it covers a large area, so the cold weather conditions in different cities in the region also have some differences (Fig. 2). In this paper, the climate and latitude as the standard, the selection of China's three cities in cold area for the study on behalf of the city: Mohe, Harbin, Xining. Mohe latitude north latitude 53.48°, the highest latitude city in China; Harbin latitude north latitude 45.22°; Xining latitude 36.56°. Respectively, a difference of about three cities latitude is about 10°, covering China's cold regions.

From winter October to April, the average temperature of the three cities increased with decreasing latitude in Mohe monthly average temperature is much lower than the other Figure 2 shows two cities; in the summer, the bit Xining and Qinghai-Tibet Plateau at the highest latitude Mohe average temperature similar; the highest average summer temperature of Harbin. Instructions, temperature is not only relevant to latitude but also highly relevant to the city's altitude.

Building low energy: There are two methods of building energy consumption is defined: generalized building energy consumption is from the manufacture of building materials, construction, energy consumption of the whole process has been used for construction; building energy narrow sense, namely energy consumption of the building, it means to meet architecture Indoor environmental requirements (building indoor environment includes thermal environment, light environment, air environment and sound environment), construction equipment energy consumption during operation. Building energy consumption of the paper refers to the narrow building energy consumption. Building energy consumption refers to buildings under indoor environmental conditions required to meet the rational use of energy, constantly improve energy efficiency, and reduce energy consumption as much as possible.

Building energy consumption refers to buildings under indoor environmental conditions required to meet the rational use of energy, constantly improve energy efficiency, and reduce energy consumption as much as possible. Since this paper is to study the design of the stadium construction in cold area, and thus mainly related to the climate and closely associated with building outdoor indoor thermal environment, building energy consumption light environment and wind environment issues. When the weather outside resources can not meet the requirements of the user indoor thermal environment, light environment and wind environmental requirements, they will each take a human approach to complement its energy consumption corresponding to thermal energy, lighting and ventilation energy consumption. Wherein the indoor thermal environment is the most important part of the indoor environment, it corresponds to the thermal energy contained building heating and cooling energy consumption in two parts. In cold areas due to winter time is longer, so the heat energy used for heating the building only is far higher than the energy consumption for lighting and ventilation.
As China's social and economic development, new service industries (such as banking, insurance, management, design, etc.) will have a greater future development, modern office requires a well-lit office space, and a variety of cable clouds widely used in floor and the computer, only electricity is based can be achieved. Additional office buildings will be new challenges for the supply of electrical energy. Not only the depth of the floor over the reach of natural light, and although you can use natural ventilation way to maintain air quality, but not in this way to disperse most of the office buildings used by the video display device generated heat. Artificial lighting is a major consumer of office buildings channel energy costs, 50% of the total electricity consumption. If the floor is very wide, we need to consume more energy than heating lighting. In addition, in summer, artificial lighting also need to consume extra energy to mechanical refrigeration. The use of natural light (by building a patio and into the deep narrow floor) instead of artificial lighting can save 40% -50% of energy consumption.

III. BUILDING ENERGY RESEARCH METHODS

Static energy analysis method: The basic principle of static energy analysis method is to ten days each heating period or heating period, the heat consumption of each month is calculated according to the steady-state heat transfer theory, regardless of the regenerative effect of the various parts of the building envelope. The method of static energy analysis are: the effective heat transfer coefficient, degree days method, temperature and frequency method, heat load frequency table method and equivalent full load running time method.

(1) The effective heat transfer coefficient: the effective heat transfer coefficient of the main features of the method is to replace the original effective heat transfer coefficient of heat transfer coefficient of heat transfer coefficient generally refers to the unit temperature difference, heat transfer per unit area per unit time of. Here, the heat is only caused by the temperature difference between both sides. In fact, in the envelope, not only on both sides of the air temperature difference caused by the presence of heat consumption, but also by the presence of heat gain due to solar radiation and heat loss caused by radiation to the sky, these three parts is the algebraic sum of the net heat rate envelope structure. In the unit temperature difference, the net heat consumption per unit area per unit time, namely the effective heat transfer coefficient. "Energy conservation design standard (heating residential buildings)," the approach is effective heat transfer coefficient.

(2) the degree days method: live method is a simplified calculation method. It is based on two assumptions, that is, from a long-term average, while the average daily outdoor temperature is equal to a reference temperature, solar radiation and indoor heat gain can fully compensate for the heat loss of the building and the heating system does not need to run; in addition, heating power consumption is proportional to the difference between the reference temperature and the average temperature of the outdoor day. The United States will take the reference temperature is 18.3 C. Heating degree days is the difference between the average daily outdoor temperature difference between the reference temperature and the heating of the day, the sum of products.

(3) Temperature and frequency method: temperature frequency versus a live method, it is more adapted to the indoor load dominates, with indoor and outdoor temperature and the load is not building (such as large commercial buildings) linear relationship. BIN is the transient thermal different outdoor dry bulb temperature (cold) load value multiplied by the number of hours the temperature appears to calculated load size. General temperature frequency equals 3 ℃ ~ 5 ℃, take into account the opening stop unit and equipment usage, generally the daily work load calculation is divided into three sections.

Weighting coefficient: The method is between static and dynamic thermal equilibrium calculation method of a compromise. Weighting coefficient is deduced from the Z function transfer method from, the weights have two groups: the weights and the air was hot right temperature coefficient. The former is about to get heat into the cold (hot) load of relationship, such as Formula 1. Heat gain weight coefficient is a series of arguments, the number determines the thermal storage building envelope and heat storage in the later period of time how the release. Air temperature coefficient is about right indoor temperature and room loads relationship.

\[
Q(t) = v_q g(t) + v_q q(t-1) + \ldots - v_0 Q(t-1) - v_0 Q(t-2) \ldots (1)
\]

\[
T(t) = [Q(T) - ER(t)] + p_0 [Q(t-1) - ER(t-1)] + \ldots + g(T(t-1) - g(T(t-2) - \ldots / g_0 (2)
\]

Where T represents indoor air temperature; \( q(t) \) represents heat on the time of t; \( Q(t) \) represents cooling load on the time of t; \( ER(t) \) represents energy that air conditioning system provides on the time of t;

Weighting coefficient has two assumptions. One is the assumption that envelope thermal process model is linear, and become the sum total of the cooling load. The second is the assumption that the system parameters affecting the weights are constant, regardless of the time. These two assumptions to some extent undermine the accuracy of the simulation results. Developed by the US Department of Energy DOE-2 energy simulation software is to use this method.

Heat balance: Heat balance method according to the first law of thermodynamics (energy conservation) to calculate energy consumption, so it is more theoretical number, less than the weighting coefficient assumptions, but are complex and time-consuming computer more. Heat balance by the outer surface of the building heat balance, heat balance building body, the inner surface of the heat balance and composition of the outdoor air heat balance equations, simultaneous equations can be solved for each surface and indoor air temperature, once the temperature know, you can calculate indoor cooling and heating load.

Because of the heat balance method is described in detail room heat transfer process, through energy conservation
formula to calculate the instantaneous load. It can also be used cold radiation or radiation heating systems, these radiation sources as a surface indoors, column write the corresponding inner surface heat balance associated with other simultaneous solution, can calculate the effects of radiation on the indoor environment, in which point weighting coefficient is incomparable. By the US Army Construction Engineering Research Laboratory developed this method using the BLAST software.

$$q_i(t) = h_i(T_i(t) - T_a(t)) + \sum_{k=1}^{n} h_{ik} (T_k(t) - T_i(t)) + R_i$$

(3)

Where $q_i(t)$ represents the heat on i-th surface at the time of t.

$$Q(t) = \sum_{i=1}^{n} S_i h_i (T_i(t) - T_a(t)) +$$

(4)

$$m(t) C_p (T_i(t) - T_{in})(t) + Q_i(t)$$

$q_i(t)$ represents the transfer coefficient heat on i-th surface.

$S_i$ Represents the area of the surface $I_i$.

Software rationale: Energy Plus program load calculation methods used by the room heat balance. The basic assumption for the room air temperature is consistent balance. Wall heat transfer model of the next section will effect the amount of interference inside and outside, the room heat balance model were described, especially for Energy Plus to calculate wall thermal reactivity coefficient state space method is described in detail.

Stadium interior design is light environment: the user requirements of the primary and ultimate goal, to meet the requirements of different sports and viewers requirements; meet the technical requirements of lighting televised; it should be done to reduce shadows and glare; to meet users' needs under the premise of natural light as a priority, energy saving, economical and reasonable. Our Gym Indoor lighting standards may refer a number of national standards, such as "civil lighting design standards GBJ133", "architectural lighting design standards GB/T50033-2001" and "Architectural lighting design standards GB50034-2004"; grade above the stadium also shall comply with the provisions of the relevant international sports organizations. Based on the above criteria and requirements, stadium lighting and illumination uniformity to the illumination as shown in Table 1.

**Table 1. Illumination and illumination uniformity of gymnasiums**

<table>
<thead>
<tr>
<th>Illuminance (lux)</th>
<th>Amateur</th>
<th>National competition</th>
<th>Professional level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physical Training</td>
<td>Non-competitive, recreational activities</td>
<td>National competition</td>
</tr>
<tr>
<td>U1</td>
<td>150</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>U2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Core stadium building is the venue, the basketball venue above article only illumination computation object, the surrounding space and the audience seating illumination is not required. According to China 'stadium lighting design and testing standards "in the provisions of the minimum requirements for the basketball court, the average of the top natural light illumination at a height of not less than 1 m 150lx, the level of illumination uniformity U1 (minimum illumination / maximum illumination) shall not be less than 0.3, the level of illumination uniformity U2 (minimum illumination / average illumination) shall not be less than 0.5.

Illumination calculation: Illuminance on the working plane refers accepted flux per unit area. In order to meet the various requirements of different sports competitions or training programs, national standards for different classes of gymnasium hall illumination game has strict rules. Our nation is at gymnasium design, based on the specific needs of interior design needs. Indoor illumination daylighting calculation method is as follows.

Calculation outdoor horizontal solar illumination as the formula 5:

$$E_u = a \sin \theta$$

(5)

Where $E_u$ -->Full overcast sky diffuse irradiation, no shelter in the outdoor illumination level surface diffuse light from the sky generated, lx; $\theta$ -- Solar elevation angle from the horizontal plane; $a$ --Solar radiation illumination, lx.

Indoor natural light illumination of a point can be calculated by the following equation 6:

$$E_u = C \cdot E_u$$

(6)

Where $E_u$ --Full overcast sky diffuse irradiation, and the outdoor illumination of a point at the same time, same place, indoor illumination plane given by the diffuse sky light generated, lx; $C$ -- Indoor lighting coefficient of a point.

Daylight factor gymnasium skylights can be calculated as follows 7

$$C_n = C_d \cdot (\tau - \tau_1 \cdot \tau_2 \cdot \tau_3) \cdot K_p \cdot K_r \cdot K_s \cdot K_f$$

(7)

Where $C_n$ --Full overcast sky diffuse irradiation, the venue illumination calculation plane skylights of the average daylight factor; $C_d$ --Skylight window opening daylight factor. Skylight area, floor area and building related to the length, the specific values can be found from China "architectural lighting design standards" in $\tau$ -- Transmittance of light materials.

IV. PREPARE YOUR PAPER BEFORE STYLING

With the rapid development in recent years and national energy indicators insulation technology continues to improve, continue to expand the application of wall insulation, energy-saving wall insulation is an important part of building energy efficiency, insulation type dry mortar in the wall reflects the application of thermal insulation unique
performance advantages, will gradually replace the traditional plastering mortar, into the broader field of energy.

Glass beads is the use of a glassy mineral, through special high-temperature process from production, is a lightweight insulating refractory particulate material, stable physical and chemical properties, with fire, thermal insulation, sound-absorbing and energy-saving properties. Use alternative to traditional glass beads and polystyrene particles as ordinary perlite insulation mortar dry mix has a unique excellent thermal resistance, anti-aging weather resistance, fire resistance can be made up by the polystyrene particles and the general perlite insulation mortar as many defects and deficiencies.

The above saving in energy consumption of residential housing and the effect of the traditional winter design day on January 14 and the heating period of comparison, energy-saving building model I can significantly reduce energy consumption.

In order to achieve the purpose office building energy consumption, but also we need the support of technical strength. Low-energy office building energy conservation policy is by optimizing the design for the building systems to achieve, with the development of science and technology of new energy-efficient technologies emerging, the current main technologies: (1) External structure of energy-saving technology. (2) Outside the windows, walls of energy-saving technologies. (3) Concrete heating and cooling technology.

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Thickness(mm)</th>
<th>Density(kg/m³)</th>
<th>Specific Heat</th>
<th>Thermal Conductivity[W/(m.k)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass beads of insulation surface</td>
<td>20</td>
<td>100</td>
<td>0.84</td>
<td>0.037</td>
</tr>
<tr>
<td>Polystyrene board</td>
<td>80</td>
<td>30</td>
<td>1.38</td>
<td>0.042</td>
</tr>
<tr>
<td>Aerated Concrete</td>
<td>300</td>
<td>700</td>
<td>1.05</td>
<td>0.22</td>
</tr>
<tr>
<td>Inside plaster with cement mortar</td>
<td>20</td>
<td>1800</td>
<td>1.05</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Fig. (1). Comparison of energy consumption of the winter design day

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V. CONCLUSION

"Low consumption, low investment, low pollution, moderate consumption" conservation-oriented development model is the major trend of building development. As a developing country, in the direction of the technical level of low-energy office building must be combined with China's national conditions, "Beijing Charter" that: "From a technical point of view the complexity of low-technology, light technology, high-tech are different and vary greatly, so each design project must choose the appropriate technology route, seek specific integrated approach; also necessary to build according to their own local conditions, for a variety of technologies to utilization, inheritance, improvement and innovation.

"17 architect Norman Foster Gan this release:" When we decided to use some of the techniques are based on regional conditions to determine, whether or not its’ advanced "abandon the blind pursuit of the so-called high-tech energy technology. A combination of local conditions of climate and local materials, the main direction of technology is saving design.

Taken together, the suitability of the energy-saving design program will generate positive interaction with local natural, economic and social environment, a comprehensive benefits to achieve the best technical systems. Therefore, the promotion of building development concept was designed Suitability ‘mainstream direction of China's future low-energy office building.

In order to reduce the negative impact on the ecological environment gymnasium and energy caused by environmental adaptation of architectural design is based on low-energy gymnasium responsibilities of the architect's work. In the stadium design should enable the architectural design elements to maximize the adaptation with the local climatic conditions, to improve the gymnasium indoor environmental quality, attention to the environment and sustainable development design, design ideas to promote a return to the architectural design of the stadium development, and to achieve the purpose of energy efficiency in buildings.

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REFERENCES


