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Study on climate adaptability architecture design in cold region: A case study of Beijing urban area

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Abstract: *Climate is the main factor determining architectural design, which brings great challenges to architectural design. Therefore, the thinking and technical means of architectural design must reflect the characteristics of adapting to local conditions. The characteristics of long winter and long-term low temperature environment in cold regions also put forward higher requirements for architectural design. At present, there are still many problems in the architectural design of cold regions, which seriously affect the local economic construction. Therefore, this paper studies the adaptability of architectural design in cold regions from the perspective of climate adaptability by taking the urban area of Beijing as an example.*

Keywords: *Cold regions, climate adaptability, architectural design*

1. Overview of climate-adaptive building design

Climatic conditions, geographical environment and other factors in the cold regions in the north [1] have a very obvious impact on local architectural design projects, and many modern architectural design ideas and construction technologies are difficult to be effectively applied and developed. Due to the low average annual rainfall in the cold regions in the north, they are characterized by hot summer and cold winter, dry climate, more wind and sand, and large temperature difference between seasons and day and night, etc. Such special climatic conditions have higher requirements and influences on architectural design [2]. Under the influence of climate adaptability factors, architectural design in cold regions in the north should meet the basic needs of insulation, moisture, cold and freezing in winter, and some buildings in summer need to have functions such as heat dissipation, heat insulation, cooling and dehumidification. The building should be set in the sunny and sheltered area, and try to ensure that the building has a longer sunshine time; The ratio of the outer surface of the building to its volume should be reduced as much as possible, and there should be no more convex and concave structures in the whole building. This must be based on a scientific analysis of climate adaptation.

Climate adaptability Architectural design takes ecological architectural design as the purpose, comprehensively considering the climatic characteristics within the regional characteristics of buildings, including wind environment (wind direction and speed), temperature, precipitation, humidity, sunshine and other influencing factors, and determines the current architectural design needs and contents through the statistical record data table of historical and recent climate conditions to ensure that the basis of architectural design can be followed. To realize the architectural design has pertinence and reasonable principle [3].

Climate adaptable architecture is the architecture that ADAPTS to the local climate conditions and satisfies the thermal comfort of the user space. With the continuous improvement of China's economic level, people's standards for indoor environmental comfort are increasing day by day. Through user experience and feedback, many architectural designs guided by traditional thinking failed to fully consider the factors adapting to local climate conditions, but only adopted common design techniques, resulting in insufficient comfort of buildings, or cold, or damp, or stuffy and draft-free. So a lot of heating and cooling equipment had to be used to solve the comfort problem. Some of the more serious problems can not be completely improved by relying only on construction equipment, resulting in increasing energy consumption and carbon emissions during building operation.

According to China's current national standard "Civil building thermal design Code" GB50176 building thermal design zoning standards, the country is mainly divided into five regions, cold areas,

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cold areas, hot summer and cold winter areas, hot summer and warm winter areas, mild areas. It is mainly reflected in the influence of meteorological basic elements on the thermal insulation design of buildings and enclosures. The average temperature of the coldest month (January) and hottest month (July) is used as the main index, and the number of days with the cumulative average daily temperature ≤5°C and ≥25°C is used as the auxiliary index. Downtown Beijing is located in a cold area.

2. Influencing factors of architectural design for climate adaptability in cold regions

The study of architectural design based on climate adaptability factors must be based on the utilization of wind, light, solar radiation and other energy in the climate range. Heating, cooling, and lighting are the most important uses of energy in the building and have a strong influence on the form of the building's exterior. Since the external form of a building is the result of the comprehensive influence of many energy factors, these energy factors should be taken into account in the process of architectural design [4].

The external climate of the building can be regarded as the medium surrounding the building, which communicates with the interior through the opening of the building or transmits heat through the non-breathable shell. The environment around the indoor people is a continuation of the outdoor environment. It is powered by heated land and water. The convection of air masses over land and water, the processes of evaporation and precipitation caused by air mass convection, changes in air temperature and atmospheric pressure, and the movement of air masses caused by the rotation of the Earth all constitute the climate system characterized by changes in time and space.

Different climatic conditions will bring different design requirements to the climate-adaptive architectural design, and will also have a huge impact on the shape of the building. In the cold areas in northern China, it is necessary to carry out wind, cold and snow protection design to meet the comfort and coordination of the indoor environment. The main climatic factors affecting the building form are climate and region, wind environment, solar radiation, atmospheric humidity and precipitation.

2.1. Climate and regional influencing factors

The influence of climatic factors and regional factors on the form and layout of the building is an interaction and unity of opposites. Different geographical environments determine different temperature and precipitation, so they correspond to different climate types. People's requirements for architecture are also different, so the regional characteristics of architecture are produced. The regionality of architecture is ultimately determined by climate factors. For traditional architecture, after years of development, relatively representative coastal dwellings have been formed in coastal areas of temperate monsoon climate, subtropical monsoon climate and tropical monsoon climate. However, for contemporary architecture, due to global integration, standardized design and highly developed technology, there is not much difference between architecture in coastal areas and architecture in inland areas. There is not much difference between southern architecture and northern architecture.

Climate and geography are always important factors to consider in architectural design. Only from the perspective of climate adaptability, buildings that adapt to local climate characteristics and regional characteristics can not only meet the requirements of energy conservation and environmental protection, improve the user's sense of identity and suitability, but also improve the cultural environment and microclimate environment of the site and the surrounding area. Therefore, the architectural design that ADAPTS to the local climate characteristics and regional characteristics is to take various factors such as natural ecology, regional culture, and technology use function into consideration in order to achieve the best design results. However, the established basic technical requirements of "four sections and one environmental protection" cannot meet the architectural design requirements of the "two-carbon" goal of carbon peak and carbon neutrality in the new era. It is necessary to fully combine the ecological, cultural and construction technology factors of different regions to build a contemporary local green building system that ADAPTS to the climate characteristics and regional characteristics of Beijing.

2.2. Influencing factors of wind environment index

In the design of buildings with climate adaptability in the cold regions in the north, we must focus on the wind environment where the building is located. In the cold regions, the dominant wind direction in winter is the northwest wind, the wind speed is large, and the cold wind is cold. Therefore, if we want to keep the indoor environment warm and energy saving in the cold wind, we need to

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optimize the design of the building in terms of air exchange, taking the wind direction, wind speed and other issues into full consideration. To ensure the comfort of the building.

Fully consider the influence of wind environment on architectural design and construction technology. In the stage of architectural design engineering, there will be a phenomenon that designers learn from the excellent technology and construction experience in the south, but in the actual application process, many advanced technologies and excellent concepts can not be effectively applied in construction projects or can not give full play to their own technical advantages, mainly because of the unique climate environment and geographical conditions in the cold area of Beijing. Therefore, in the process of architectural design, attention should be paid to the actual impact of special factors such as wind environment on architectural projects, and targeted, scientific and reasonable climate-adaptive architectural design in urban Beijing in cold areas should be carried out to ensure the adaptability of buildings to wind environment. To provide people with more high-quality architectural space, and in the continuous exploration and practice to build a regional characteristics of the cold area of Beijing urban climate adaptive architecture design system.

2.3. Influencing factors of solar radiation

As one of the main sources of life on earth, solar radiation will directly affect the degree of temperature change, and is the most important factor in the formation of natural climate. The main part of solar radiation is thermal radiation in the form of light and electromagnetic waves, and the main influence of solar radiation on buildings is the optical effect. The so-called optical effect refers to the visible light generated in the process of solar radiation, which will have a huge impact on the lighting of buildings and indoor lighting. In addition, the main heat source generated by solar radiation for the building is the thermal effect, the so-called thermal effect refers to the building wall and some indoor air environment under the action of solar radiation to produce heating effect, so that the indoor warm effect. At the same time, the radiation of the sun will also have a certain impact on the human body, the ultraviolet rays in the sun will produce radiation on the human body, and will damage the surface of the building materials.

In the northern summer, the sun exposure time is long, the light is strong, the outdoor temperature is high, the solar radiation often makes the indoor temperature is too high, but this situation in the winter will make the indoor warm, can save heating fuel, but also to ensure the indoor temperature, is a very clean natural energy.

In the cold areas of our country, the rational and effective use of solar radiation can save limited energy and resources, can play the advantage of sufficient sunlight, sunlight into energy, and realize the sustainable development of energy resource utilization.

2.4. Influencing factors of air temperature

Air temperature refers to a sign of regional heat conditions, is a very important climate factor, air temperature is referred to as air temperature. The main influencing factors of air temperature are the condition of air flow, the degree of solar irradiation and the terrain, etc. The solar irradiance has the greatest influence on the temperature. The higher the degree of solar radiation, the greater the increase of temperature. At the same time, the influence of air temperature on the building is also huge. When the temperature is high, the indoor temperature will increase through heat conduction and other ways. Such changes in indoor temperature will have an impact on the calculation of the thermal performance of the building, and the temperature will determine the intensity of the building's heating facilities and the parameters of indoor ventilation facilities. For example, in the cold area of Beijing, the outdoor temperature is low, and the main purpose of architectural design is to ensure that the outdoor temperature will not have too serious impact on the indoor temperature and prevent the human body from becoming uncomfortable. Generally speaking, meteorological data can effectively display the temperature situation of which region, and the design can guide the architectural design of cold regions according to the meteorological data, and strive to solve the impact of too low ambient temperature through certain measures.

2.5. Influencing factors of atmospheric humidity and precipitation

Atmospheric humidity refers to the amount of water vapor in the air. The main source of water vapor in the atmosphere is the evaporation of moist surface water vapor into the air. Temperature and

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pressure have an important effect on the humidity of the atmosphere. For both the human body and the building, if the water vapor content in the air is too high, the humid environment will produce mold, which will affect people's health and the built environment of life. The humidity of the atmosphere will make the building materials decay, reduce the service life, and even cause chemical reactions in the materials, producing substances harmful to the human body.

Precipitation is the main factor affecting humidity. Most of the water sources in the surface environment circulate and flow through precipitation, and water is the source of life, which will have an impact on both human beings and architectural design. For example, high precipitation in humid areas will cause water leakage in some buildings, resulting in moisture condensation. The disadvantage is that it will reduce the insulation efficiency of the house, and it is necessary to choose waterproof materials, so as to avoid deformation and even cracks under the action of long-term rain, affecting the life of the building. In the cold area of Beijing, there is less precipitation, and most of the buildings are designed as heavy cold-proof walls with poor waterproof degree. Because most of the precipitation continues in summer, winter is mainly dominated by snow, and the time is longer. Therefore, it is necessary for the house to resist the invasion of cold wind and ice and snow to ensure the winter indoor cold resistance.

3. Climate adaptive architectural form design strategies in cold regions

3.1. Strategies for making full use of climate and regional architectural form design

Influenced by specific climatic environment, regional environment and folk culture, the architectural shape design and construction technology of traditional buildings around the world vary greatly, but the core principle is the same, that is, make full use of local favorable climate and regional factors, reasonably adjust unfavorable microclimate and regional factors through green ecological means, so as to adapt buildings to local microclimate. Meet people's comfortable living environment. While making full use of local favorable climate and regional factors, the building comfort level should be improved to make the building more comfortable and energy efficient [5].

In architectural design, according to the requirements of planning and design, building monomer design, building envelope design and building structure design, the design stage is a gradual transition from macro to meso and then to micro. Adjusting indoor and outdoor microclimate environment is one of the most important stages in architectural shape design, which has a guiding effect on the later design. If the adaptation of the building microclimate is considered and compensated in the later stage, it is easy to fall into the limitations of technology and materials, which may pay higher costs, increase more energy consumption and carbon emissions, and it is difficult to achieve better results. Therefore, it is necessary to carefully analyze the relationship between the environment and the surrounding environment within the red line of the building and the specific location of the building before the architectural design, especially the site environment design. From the perspective of small climate, when choosing a site, the primary consideration is whether the microclimate of the site is suitable for the future use and development of the building. From this point of view, the relationship between location and surrounding natural environment and urban environment is deeply analyzed and discussed, and the current specific environmental characteristics and basic needs are pre-evaluated. It is not only necessary to provide sufficient solar radiation and activity space, but also to improve the microclimate of the site to provide a "breathable space" for the building. In the process of microclimate control, the location design of architectural design is the primary consideration. The design of this stage will directly affect the comfort and health of indoor and outdoor microclimates, especially in residential buildings in cold areas where heating demand is a major issue [6].

3.2. Strategy of architectural shape design for rational use of wind environment

(1) Influence of wind environment on external form of architectural design

The external form of the building mainly refers to the structure of the building roof and the outer facade. From the perspective of natural wind, the wind environment around the building will determine the actual design form of the building to a certain extent. In order to ensure the effect of air circulation inside the building, different ventilation methods are selected for different building forms, including guided air flow, convection ventilation, skin preheating air, etc. Architectural designers should combine the local climate, effectively design the external shape and internal space of the building, solve the ventilation problem skillfully with appropriate technical means, and reflect the energy-saving effect of

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natural ventilation in function, so as to bring people a comfortable and livable living environment.

(2) Influence of wind environment on interior space of architectural design

Architectural interior space design includes architectural graphic design and section design. The wind environment index will affect the interior space design of the building. In the process of interior space design of the building, the principles of hot pressure and wind pressure should be used, and the building layout should be combined to ensure that the building has good ventilation, so as to improve the interior environment of the building, and realize energy saving and carbon emission reduction in the construction field.

The optimal design of the building plane based on the wind environment needs to make the outdoor natural wind flow to each room in the building in multiple directions, while ensuring the smooth ventilation path of each room, preventing the phenomenon of natural wind interruption as much as possible, so as to form a good natural ventilation environment. In actual graphic design, the layout of small deep and large open room is often used to ensure that the room is spacious and neat, so as to ensure the smooth flow of natural wind, improve the smooth flow of indoor air, and ensure the wind environment effect of the building.

The building profile is optimized to make the outdoor natural wind effectively run through the whole building from bottom to top, so as to achieve the purpose of indoor and outdoor air exchange. In the design, the principle of thermal pressure difference is effectively used to raise the height of the internal space of the building, and at the same time, the air outlet is set on the top of the building to form the upper and lower through space, guiding the natural wind to flow smoothly, so that the hot air trapped in the room can be discharged smoothly.

3.3. Strategies for building shape design with solar radiation

In the cold areas of our country, the most important goal is heating, making full use of long-term solar radiation resources, and ensuring indoor temperature under the premise of effective energy saving. At the same time, the role of solar radiation is not only the transfer of thermal energy, but also the ultraviolet rays in the solar radiation can effectively kill most bacteria in the air and ensure the cleanliness of the building interior. Therefore, in the cold areas of our country, it is necessary to ensure that other buildings will not be shielded when they can obtain solar radiation, which requires the layout of the building to adapt to the climate of the cold area, such as the main functional area of the building facing south, and the window area is larger, as far as possible to strive for solar radiation, while the north is as far as possible to arrange the secondary functional area of the building, and as few Windows as possible. Open the window on a smaller scale.

The common arrangement of buildings is the determinant emission, all buildings are unified in the direction of direct solar radiation, and a reasonable distance between buildings should be maintained to ensure that the lowest floor can also obtain sufficient solar radiation. This way can maximize the use of the thermal effect of solar radiation, maintain the indoor temperature and light, and ensure the temperature while achieving effective energy saving.

3.4. Strategies for building ventilation, wind shelter and building orientation in architectural form design

(1) Building ventilation and shelter form indoor and outdoor heat exchange

In the cold areas of our country, the flow of cold air in winter will take away most of the heat in the room, resulting in serious heat loss. Therefore, if you want to effectively alleviate this unfavorable situation, you need to ensure the reasonable design of ventilation facilities. Cold areas in the summer need to ensure that the ventilation condition is good, so that the indoor temperature is reduced, bring people a feeling of comfort, winter needs to ensure that the indoor air is fresh premise, indoor heat will not be taken away by the outdoor cold air, and reduce the indoor temperature.

(2) Building layout and orientation are mainly affected by solar radiation

Because 10:00 ~ 14:00 solar radiation accounts for 60% of the total solar radiation. Therefore, the optimal direction of building layout and orientation should be selected according to regional meteorological data, which can effectively improve the utilization rate of solar radiation, improve indoor comfort, and reduce heating energy consumption.

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(3) Building orientation and comfort of indoor microclimate environment largely depend on ventilation efficiency

Under normal circumstances, the ventilation effect of oblique wind blowing into the room is better than that of direct wind blowing into the room, and the wind entering the building at a 45 degree Angle of incidence reduces the indoor wind speed by 15% to 20%, but the average wind speed is larger and the indoor air distribution is better. When the wind blows into the room, although it will affect the indoor wind speed and air flow, the vortex area behind the house is greatly reduced, and the ventilation effect covers a larger area.

3.5. Introduce the shape design strategy of natural landscape architecture

In the process of climate-adaptive building design, making full use of the natural landscape can not only integrate the building with the surrounding environment, but also achieve the function of wind and cold protection through scientific layout. Common technical methods are:

(1) The layout design of the architectural complex should follow the climate characteristics of the cold region, and the scientific layout should make the outermost buildings within the architectural complex form a natural wind and cold barrier to avoid the invasion of the cold current.

(2) Minimize the size coefficient of the building and reduce the contact area between the building and the environment. Reducing the contact area can reduce the heat loss of the peripheral structure. Proper consideration can be given to building vertical greening.

(3) Outdoor site design under the premise of economic conditions and external environment permits, fully consider the use of landscape water, landscape vegetation and other methods for building site design, which can adjust regional microclimate environment, reduce energy consumption and reduce carbon emissions.

(4) The interior design mostly adopts transitional space schemes, such as halls, balconies, roof gardens, etc., as indoor and outdoor thermal buffer zones to reduce the impact of external environment on the interior and achieve the purpose of seeking benefits and avoiding hazards.

3.6. Strategy of architectural technology assisting architectural form design

In order to achieve the best temperature and humidity, ventilation and heating equipment can be used to warm the indoor temperature, discharge the indoor dirty air and introduce the outdoor fresh air, the use of scientific building structures and a variety of new building materials. For example, energy glass can provide a warmer and more comfortable environment for people in cold climates.

According to the climate characteristics of the cold region, adaptive technology strategies are used to ensure the external form and use function of the building on the premise of minimizing resource consumption, so that the building has good climate adaptability, such as the use of large Windows with high light transmittance. In order to keep the indoor temperature constant and not consume too much energy, high-tech vacuum glass and coated glass can be used. For large buildings, the use of double-layer air supply energy-saving curtain wall technology can effectively use sunlight, so that the air between the glass floor can be heated and transported to the indoor space, playing the role of air conditioning, ventilation and so on.

4. Problems of climate-adaptive architectural design in cold regions

Due to the low winter temperature in the cold region, the temperature will remain below zero for more than four months. Therefore, in the design of climate-adaptive buildings in cold regions, the cold resistance of the outer structure and the thermal insulation capacity of the building itself must be considered. In traditional architectural design, thick walls, small Windows, closed balconies and other design techniques are often used to consider the maximum use of outdoor sunlight. However, in the practice of architectural design in cold areas, architects excessively pursue the aesthetic and lighting effects of buildings, and many people directly copy the design method of southern buildings, at the expense of building size coefficient, increase the heat dissipation of buildings, and greatly reduce the thermal insulation effect of buildings, only for the pursuit of architectural permeability. A large area of Windows has also become a weak link in building insulation, and the balcony as a buffer space between indoor and outdoor does not take into account the requirements of cold resistance. Therefore,

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to make the indoor temperature comfortable, you must consume a lot of energy. This kind of architectural design deviates from the main principles of building in cold areas and does not meet the requirements of energy conservation and environmental protection of modern buildings.

The architectural landscape and the surrounding environment of the building play a great role in the overall aesthetic effect and use function of the building. The design of the built environment should strictly follow the local regional environment and climate characteristics. However, some architectural designs use large areas of green space or outdoor ponds, which will be abandoned after winter, and even become potential sources of pollution, which can not be used in nearly half a year, resulting in a serious waste of land resources.

5. Conclusion

Regional differences in climate adaptive building design are obvious. In practical work, scientific design should be carried out according to the local geographical location, regional environment and climate characteristics. In the face of various problems existing in the current architectural design work, we can adopt adaptive technical strategies, give full play to the subjective initiative, make the design scheme more scientific and reasonable, and serve the local economic construction and people's life. Through the reasonable planning of the natural landscape, the humanized design concept and environmental characteristics can be well combined to improve the local microclimate environment of the building. In the design of climate adaptable buildings in cold regions, the temperature change rule and the duration of winter should be fully considered. On the basis of understanding the main wind direction in winter, the combination of natural ecology and architectural design is made full use of the local topography and other characteristics, so as to improve the environmental adaptability of buildings.

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