Research on Climate Adaptation Design Strategy Driven by Spatial Performance from the Perspective of Land-Based Rationalism: Taking the Academic Complex Project in Central School of Communist Youth League of China as an Example

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Abstract. With the rapid urban development, the construction of public buildings in China has been greatly promoted, and the problem of large energy consumption of public buildings has also become increasingly prominent, with a stronger demand for close combination of public buildings and passive design. Based on the characteristics of theater space, this paper mainly studies the passive design method of large space, excellently integrates climate adaptability design technology with passive building design strategy, and explores the optimal passive design scheme for theater buildings, by taking the academic complex project in Central School of Communist Youth League of China as an example, with passive priority and active optimization for the principle from the aspects of climate adaptation and indoor environment comfort.

1. Introduction

Land-Based Rationalism, which represents a position or a cultural strategy, can be described as a methodology and a set of values for solving problem \textsuperscript{[1]}. Land-Based refers to the active adaptation to and respect for the objective environment such as local culture, natural environment and historical heritage, as well as the conscious embodiment of national consciousness \textsuperscript{[2]}. Energy crisis, environmental damage and climate change have become global crises endangering human survival, raising concerns about climate and environmental change in the field of construction, and thus green buildings emerge as the times require. However, green building should not be an energy-saving building piled with technologies, but an innovation based on native culture and reflecting natural aesthetics \textsuperscript{[3]}.

Therefore, we need to carry out scientific, systematic and in-depth research, establish a Land-Based design method and appropriate technology system with global vision and local characteristics, so as to set up an innovation platform and explore the road of human settlements construction with Chinese cultural characteristics and the sustainable development of green building creation under the new situation.

The research on green public building design, design mechanism, methods and technology system based on climate response mechanism, the development and application of auxiliary design tools, and the improvement of building energy consumption and emissions are considered as important strategies for the construction field to respond to the global climate change problem. Driven by spatial performance, climate adaptation design maximally saves energy and resources and reduces emissions while ensuring
the use demand and comfort. The theater building studied in this paper is a type of architectural space with high performance requirements and energy consumption, so that it is of typical significance to study the climate adaptation design of its main functional space and subsidiary space.

2. Research Methods

2.1. Design Methods of Climate-adapted Green Buildings
Climate-adapted Green Buildings refers to the passive design strategies, such as heat-insulating performance, orientation and spatial layout optimization of building envelope, to adapt to outdoor climate conditions, in order to increase the utilization of external conditions, such as wind, light and heat, while reducing the antagonistic relationship between indoor environment and climate conditions. Passive regulation means can reduce the consumption of energy and resources through the passive regulation of buildings with no or less energy consumption, which is the part of traditional buildings that need to be actively regulated through building equipment system, so that buildings can better respond to the external environment and be less affected by the external natural environment.

Buildings with climate adaptability should make full use of the local natural climate resources, and adopt appropriate architectural design strategies to mitigate the adverse impact of external climate on indoor thermal comfort environment, so as to form a hierarchical system and a design system of climate adaptability design of public buildings, for the purpose of climate regulation and energy management, with climate adaptability design of spatial form as the core.

2.2. Analysis on the Spatial Characteristics of Theater Buildings
Theater buildings refer to as a type of buildings that provide the ideal places for people’s live performing arts, and public buildings with viewing and performing space, which are not only the places for audiences to enjoy all kinds of performing arts, but also the places for social and cultural exchanges [4]. The theater building is generally composed of four basic components, namely, the auditorium (seat) space, the stage space for performance, the public space for audience, and the backstage space for actors and staff, with the basic model of spatial organization typically centered on large theater space, surrounded by other service space around on their sides or layout.

2.3. Spatial Performance category and Energy Consumption Classification
From the perspective of material space composition of architecture, the overall space of architecture is composed of structure space, equipment space and usable space. The comfort of space is mainly for usable space. The comfort of space is mainly for the use of space, and its comfort requirements and the relevant interaction with the outdoor climate can result in energy consumption differences. Therefore, the element difference and grade difference of climatic performance will occur in the usable space due to its different functions. The difference of climatic factors refers to the selective introduction, control and supplement of climatic and natural factors, such as wind, light, heat and humidity, thus forming different energy consumption mechanisms. The grade difference of climate performance refers to the degree of strictness of climate performance elements and indicators. The grade difference of climate performance of public building space can be divided into ordinary performance space, low performance space and high performance space. The grade difference of climate performance requirements means that the energy consumption grade of all kinds of building space is different, which can affect the total building energy consumption. Generally speaking, low and high performance correspond to low and high energy consumption, respectively, while the energy consumption of ordinary performance space mainly depends on the climate adaptability of the design.

2.4. Performance Category and Energy Consumption Classification of Theater Building Space
Among them, professional auditoriums, stages and VIP lounges generally belong to high-performance space, while general auditoriums or lecture halls with low requirements belong to ordinary performance space. According to functions and human needs, different spaces in the theater building can be divided
into low performance space, ordinary performance space and high performance space. The higher the space performance is, the higher the requirement of indoor environment will be, and the more equipment adjustment will be needed, and the higher the energy consumption will be. Therefore, professional auditorium, stage and VIP lounge can be generally regarded as high-performance spaces, but the general auditorium or lecture hall with low requirements as ordinary performance spaces.

| Table 1. Grade Classification of Climatic Performance in Theater Building Space |
|-------------------------------------------------------------|
| Low Performance Space | Ordinary Performance Space | High Performance Space | Variable Performance Space |
| Expected Energy Consumption | low depend on design | high | Change according to performance positioning |
| Space Functions | toilet, security inspection, equipment room, clothing room, utility room, etc | entrance hall, auditorium/lecture hall (general requirements), lounge, waiting area, exhibition, rehearsal hall, office, etc | Auditorium (high requirement), stage, VIP lounge, etc | Change according to usage |

3. Studies on Typical Case

3.1. Analysis on Site Climate Conditions
First of all, a detailed and targeted analysis of the site climate conditions is necessary for climate adaptability design method. The project is located in Beijing, with four distinct seasons, large annual temperature range and abundant sunshine. It is hot and rainy in summer, and the hot weather lasts for two months, with occasional hail and thunderstorm. It is cold and dry in winter and lasts for a longer period. It is dry in spring, with few rain and snow. While it is clear and sunny in autumn, and lasts for a shorter period, same as spring.

The thermal comfort in this region varies greatly from month to month, with the annual average temperature of 10-12 °C, the extreme lowest temperature of -27.4°C, and the extreme highest temperature of 42°C or above. The annual average daily and monthly temperature is outside the PMV comfort range from October to March of the following year, and lower than the somatosensory comfort temperature, so that heating is needed. From June to August, from June to August, it is beyond the comfortable range of PMV, higher than the comfortable temperature, and needs to be cooled.

The peak value of solar radiation in Beijing is generally concentrated in May to July, and the valley value in November to February. The trend of the peak value and valley value is consistent with the trend of the monthly dry bulb temperature.

In terms of humidity, the average monthly humidity is in the comfortable and moderate range in 10 months, but it is in the lower level of the comfortable range in most months. The climate is relatively dry, so there is a great demand for air humidification, and dehumidification is only needed in a small part of the time from July to August.

The wind direction in this area is characterized by the opposite dominant wind direction in winter and summer. In winter, the maximum wind direction is north-northwest (NNW), with the occurrence frequency of 14% and the average outdoor wind speed of 2.7m/s. In summer, the maximum wind direction is south-southeast, with the occurrence frequency of 12% and the outdoor average wind speed of 2.2 m/s. The dominant wind direction in the transition season is northeast, with an average wind speed of 2.4m/s.
3.2. Analysis on Spatial Performance Characteristics

The Academic Complex in Central School of Communist Youth League of China covers an overground construction area of 10,000 m² and an underground construction area of 21,000 m². The building is mainly used for academic hall, which belongs to the relatively common and variable architectural space type in the performance requirement standard of theater building. Its main functional space includes academic lecture hall, multi-function hall, exhibition hall, as well as the related supporting infrastructure, such as lobby, reception hall, office and archive room. Accessory space functions include traffic space, washroom, equipment room, underground garage, etc. The classification of performance requirements of each functional space is shown in Table 2.

| Spatial Types          | Density Usage Characteristics | Performance Requirement | Average Energy Consumption (Statistical Typical Value) | Proposed Comfort Parameters |
|------------------------|-------------------------------|--------------------------|-------------------------------------------------------|----------------------------|
| 800-people lecture hall| dense intermittent variable   | variable                 | heating 0.26GJ/m² without heating 55kWh/ m²           | 18–28℃                     |
| 500-people lecture hall| dense intermittent variable   | variable                 | heating 0.26GJ/m² without heating 55kWh/ m²           | 18–28℃                     |
| 300-people lecture hall| dense intermittent variable   | variable                 | heating 0.26GJ/m² without heating 55kWh/ m²           | 18–28℃                     |
| school history hall    | loose intermittent ordinary   | variable                 | heating 0.26GJ/ m² without heating 40kWh/ m²          | 20–26℃                     |
| youth movement hall    | loose intermittent ordinary   | variable                 | heating 0.26GJ/ m² without heating 40kWh/ m²          | 20–26℃                     |
| lobby                  | loose continuous low          | variable                 | heating 0.26GJ/ m² without heating 40kWh/ m²          | 18–28℃                     |
| evacuation hall        | loose intermittent low        | variable                 | heating 0.26GJ/ m² without heating 40kWh/ m²          | 18–28℃                     |
| stage                  | loose variable low            | low                      | heating 0.26GJ/ m²                                   | 18–28℃                     |
| washroom, corridor     | loose intermittent low        | low                      | heating 0.13GJ/ m² without heating 40kWh/ m²          | 18–28℃                     |
| Reception hall         | loose intermittent high       | variable                 | heating 0.26GJ/ m² without heating 55kWh/ m²          | 22–25℃                     |
| office                 | loose continuous common       | variable                 | heating 0.26GJ/ m² without heating 55kWh/ m²          | 20–26℃                     |
| garage                 | sparse continuous low         | variable                 | heating 0.17GJ/ m² without heating 9kWh/ m²           | 10℃                        |
| archives               | sparse continuous common      | variable                 | heating 0.26GJ/ m² without heating 40kWh/ m²          | 20–26℃                     |

*Note: The average energy consumption data in the table are obtained from Standard for Energy Consumption of building (GBT 51161-2016). The energy consumption value of each space type in the building is taken from the constraint value of the building type. The energy consumption data of the garage is converted according to the difference between its heating temperature and that of other spaces.
This academic complex is a combination of different performance spaces. Due to the high requirements of high-performance space on the physical environment, it is difficult to fully meet the performance requirements through the passive design strategy of no or low energy consumption. In the climate adaptability design, it is necessary to reduce the proportion of high energy consumption space as far as possible expand the space potential with no or less energy consumption, and compress the energy consumption time in the meanwhile. Therefore, the regulation mechanism of the building with the spatial form as the core corresponding to the climate can be established on the basis of the space performance, and by changing the spatial form as a measure.

The lecture hall and stage of this project are high performance space when they are used for a few demanding performing arts, ordinary performance space when they are used as ordinary lecture hall most of the time, and low performance space when there is no activity held. Therefore, it can be defined as a flexible space, so that passive measures, such as natural ventilation and natural lighting, can be taken in most of the time to improve indoor thermal comfort and environmental quality. The ancillary functional space around the lecture hall belongs to ordinary or low performance space, so that passive design strategies, such as natural ventilation and natural lighting, can be fully adopted to provide the lecture hall with service space that adapts to climate conditions and guarantee its own comfort. Accessory spaces, such as traffic, washroom, equipment room and underground garage, can be classified as low performance spaces.

3.3. Reasonable Form and Spatial Organization

Through the scientific simulation analysis and adjustment on the building shape, the design of climate adaptability can be carried out by utilizing reasonable shape and space organization to the maximum extent, so as to reduce energy consumption while ensuring comfort.

As for the design of climate adaptation form, the compact square can be formed as the unified building shape in internal space and external form, which is suitable for cold region climate by controlling its form, space, function and facade shape. The exterior area of the building shape has been optimized under the same plane area condition, that is, the shape coefficient has been reasonably controlled, with a compact building shape. The main entrance of the building has been provided with the eaves of certain width to reduce indoor sunshine in summer, and also not to reduce the entry of sunshine in winter due to the small height angle of the sun in that season.

In terms of internal space design, three lecture halls have been placed in the middle of the first floor on account of the requirements for sound, light and thermal environment, with supporting space set beside them. In terms of spatial layout, the lecture halls can be more conducive to its thermal insulation and sound insulation if they have been placed inside the building. As the space with ordinary performance requirements, the exhibition hall has been placed on the second floor to create better conditions of natural ventilation and natural lighting. The lobby, washroom, reception hall, evacuation hall and other low-performance spaces, which can serve as climate regulation spaces to construct the protective interface of the important usable spaces inside the building, have been arranged around the building. Meanwhile, the main transportation system has been designed as a route of natural ventilation between the interior space and the outside.

3.4. Optimizing Site Wind Environment to Improve Ventilation Potential

As Beijing in the cold region, attention in buildings should be paid to heat preservation and cold prevention in winter as well as heat insulation and ventilation in summer. Due to the obstruction of residential buildings on the west side of the complex, the east-west wind environment in the site has been analyzed. According to the design requirements, the building volume has been large and relatively concentrated, resulting in a relatively small surface wind pressure difference. Therefore, combined with the analysis on the sunshine and wind environment of the site, it can be considered to open part of the wall to eliminate the negative effects brought by the large volume, and appropriately increase transitional space to form an interactive relationship between the architectural space flexibility and climate adaptability.
According to the architectural form design, the wind pressure difference of building facade refers to an important index to evaluate the indoor ventilation effect. The larger the wind pressure difference is, the better the indoor ventilation will be. If there is a small wind pressure difference between the front and back of a building, the indoor ventilation effect can also be promoted through the reasonable indoor layout and window-opening design. However, if there is a relatively large wind pressure difference, it will cause damage and falling-off of the building doors and windows and external decoration. Meanwhile, if there is a large wind pressure difference before and after the building in winter, it will increase the cold air penetration, the heating energy consumption and indoor discomfort. Therefore, in order to ensure the natural ventilation in summer, attention should also be paid to the windproof of the building in winter.

3.5. Improving the Comfort in the Transition Season

As a variable performance space, variable interface design has been adopted in the lecture halls to create more gray space and other climate responsive design methods in transition season, in order to promote natural ventilation for reducing the service time of air conditioning in the inner space, and extend the comfort time in transition season.

The ventilation potential analysis was carried out by taking the functional space of the core 800-people lecture hall as an example. Because the seating of 800 people may result in a large amount of heat generation, the indoor heat can be eliminated by sending the wind with a low outdoor temperature into the hall. The lecture hall is a large space with a long horizontal ventilation distance and relatively closed surrounding interface, so that the hot pressure ventilation mode, with the vents set at the top to form a variable skin and the rise of hot air used for natural ventilation, has been preferred. However, greatly affected by outdoor conditions, pure thermal pressure ventilation can be further combined with mechanical ventilation to improve the ventilation potential. On the other hand, the opening position of the vents also exerts an important influence on the ventilation effect. Since the stage tower is relatively independent from the auditorium, the vents can be placed close to the two spaces through taking their ventilation needs into account. According to the Venturi effect, the vents have been set in the adjacent roof position of the stage tower and the highest position of the auditorium on the basis of the height of the stage tower.

4. Discussion

The requirements of theater buildings for lighting, noise and ventilation are different from those of general buildings. First of all, based on the analysis of different spatial performance requirements, the passive design strategies, such as shape optimization, reasonable spatial layout, natural ventilation and climate adaptation skin, should be adopted to form a regional climate responsive design.

Secondly, in terms of spatial layout, it is more conducive to sound insulation with the main space of the internal lecture hall located in the center, but the central position leads to less skin variable parts, making it difficult to use natural lighting. Therefore, the sunshine and lighting of the ancillary spaces, such as lobby, reception hall and traffic corridor, can be optimized for better climate adaptability of indoor environment in the lecture halls, which serve as the main functional space. At the same time, with building envelope and surrounding ancillary spaces in the passive design as a buffer, a favorable performance of heat and sound insulation can be formed in the internal space, which is very suitable for the theater buildings in cold areas.

Moreover, a large number of people usually gather and distribute in performing arts hall within a certain period of time, and the gathering of people can generate more indoor heat than ordinary buildings and affect indoor air quality. Therefore, there is a high demand for ventilation. The climate adaptation design should also focus on how to reduce the demand for mechanical ventilation.

5. Conclusion

Based on the concept of native design and adhering to the green building dominated by scientific and rational analysis, a multi-level design system and design essentials for climate adaptive design of
performing arts buildings have been proposed in this study, for the purpose of climate regulation and energy management, with climate adaptive design of spatial form as the core.

1) Having a deep understanding of site climate and put forward site design strategies

It is a prerequisite for passive design to have a better understanding of site climate. When analyzing the site climate, the comfort zone should be combined to clarify the adjustment requirements for temperature, humidity, wind speed and solar radiation in different seasons, and thus putting forward specific site design strategies.

2) Clear performance requirements and reasonable space and form design

The hierarchical relationship among functional spaces should be clarified through analysis on the performance demands of each space before the space and form design of buildings, so as to put forward design strategies to achieve No or Less Energy Consumption, which is the focus of climate adaptation design.

3) Scientific analysis and optimal design

In each stage of the design, the introduction of ventilation, daylighting and relevant simulation analysis for multi-scheme comparison can be conducive to optimizing the design scheme, improving the climate adaptability of the building, maximizing the comfort and minimizing energy consumption through the spatial form design.

Acknowledgments

This research was supported by the National Key R&D Program of China (2017YFC0702300 and 2017YFC0702305). In addition, this study was funded by The scientific and technological innovation research project of China Architecture Design & Research Group (Y2020181) by China Architecture Design & Research Group, and The Study on Interaction between Underground Space and Ecological Landscape in the View of Green Efficiency (X20020) by “Beijing Advanced Innovation Center For Future Urban Design, Beijing University of Civil Engineering And Architecture”.

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