International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 3784-3794

https://doi.org/10.70517/ijhsa464501a

Practice and Effectiveness Evaluation of Optimized Design of Thermal Environments for Building Clusters in Dense Urban Areas

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Abstract This paper selects a building group in an urban area as a blueprint, and puts forward the optimized design scheme for the thermal environment of the building group in the urban area according to the climatic and geographic conditions of the urban area. The program mainly focuses on the three aspects of planning design, building design, and the structure of the external enclosure to carry out the optimization design. APMV, indoor temperature and indoor humidity are set as the evaluation indexes of thermal environment optimization, and the simulation analysis software is determined to explore the effect of thermal environment optimization design of building groups. When the building direction changes from 12°, the indoor temperature and APMV of the building gradually increase, and the values of temperature and APMV reach the maximum at 36° (36° south-east of the building), but the average indoor humidity of the building varies from 36% to 48% during the whole process of change. The minimum change in indoor humidity occurs when the body shape coefficient is increased from 0.782 to 0.784, and the average radiant humidity reaches its maximum when the body shape coefficient is increased to 0.788, and the indoor humidity shows a monotonically increasing trend with the body shape coefficient, while the indoor temperature is the same. The total number of hours in which the natural temperature of all rooms is below 26°C throughout the year decreases by 53,929h, which is a large change of 14.04%, indicating that the practical effect of the optimal design of the thermal environment of the building complex in this paper is particularly prominent.

Index Terms thermal environment, optimal design, envelope, building complex, density urban area

I. Introduction

Among the many constituent elements of climate, the thermal environment is the most common and most directly affects the human body's sensory factors. Thermal environment refers to the environment composed of a series of factors that affect the body's perception of heat and cold, including solar radiation, atmospheric temperature, surface temperature of surrounding objects, relative humidity and airflow velocity, etc., which together act on the body and affect the body's temperature perception and health condition [1]-[3]. Accompanied by the increase of global urbanization level, the city scale is expanding, and a large number of man-made surfaces replace the original natural surfaces, which makes the thermal properties of the urban subsurface change [4]-[6]. In addition, the serious fragmentation of green areas in and around urban areas, coupled with the heat emissions from concentrated human activities, have resulted in much higher temperatures in dense urban areas than in the surrounding areas [7], [8]. This phenomenon is also known as urban heat island and heat island effect [9].

The urban thermal environment is significantly influenced by the structure, layout, characteristics and climatic conditions of urban buildings [10]. In the context of climate change and in response to the prominent thermal environment problems, the objectives at the planning level of urban building stock are to slow down the rate of climate change, to enhance the climate adaptive capacity of cities, and to reduce the vulnerability of urban systems to climate change [11]-[14]. Therefore, in urban planning decision-making, by promoting the intensive and efficient use of urban land, creating a healthy and comfortable spatial environment and ensuring the quality of the living environment by reasonably constructing the spatial layout and optimizing the elements of resource allocation, it is conducive to quantitatively and finely controlling the thermal environment of urban building clusters [15]-[18]. Qualifying, optimizing and guiding the urban planning parameters can effectively improve the quality of urban space, achieve obvious benefits in ecology, society, economy and other aspects, and create a good ecological environment foundation for subsequent design [19]-[21].

From the perspective of layout planning, indoor structure, and external enclosure structure, we analyze the direction of thermal environment optimization design of building groups, and through the evaluation of the practical effect of building optimization design, we realize a more detailed and clearer analysis of the thermal environment characteristics of the building groups in a dense urban area, and its research idea is quite innovative. Firstly, we select a building group in a city area as a research sample, considering that the optimized design of thermal environment is easily affected by climate and geographic conditions, we need to carry out the optimized design of the thermal environment of the building group from the dimensions of planning and design, architectural design, and the construction of the external enclosure structure, and use simulation and analysis software to test the performance of this paper's optimized design in the practical application of the performance.

II. Research on optimized design of thermal environment of building groups

This chapter will take into account the climatic and geographical conditions of an urban area, and optimize the design of the thermal environment of buildings in the density urban area in terms of planning and design, architectural design, and the construction of the external enclosure structure, respectively, with the energy conservation of buildings in an urban area as the guide.

II. A.Planning and design for thermal environment optimization

II. A. 1) Planning layout

The overall planning of building groups in urban areas is different from residential and public buildings, which need to meet the strict functional zoning, production flow and other special industrial operation requirements, making the overall layout of the building should not pursue too many spatial changes, but rather pay attention to the convenient transportation network, the overall and orderly spatial sequence [22], [23]. The planning layout of building groups in urban areas is considered from both planar and spatial aspects. The plan layout of building groups has rows and columns, staggered columns, peripheral, mixed, free-form, etc. From the perspective of the indoor thermal environment of the building groups, different plan layout methods also have especially different advantages and disadvantages. When the site conditions are more complex, a mixed layout is often used. Row and part of the perimeter of the combination of forms is a hybrid layout, this arrangement can be composed of a number of climate guarding unit, but also has the advantages of row sunlight ventilation, in the cold region is a better combination of building groups.

II. A. 2) Selection of orientation

The principle of orientation is to enable the complex to receive as much daylight as possible in winter, while the main spaces need to be sheltered from the prevailing winter winds, and consideration should be given to minimizing solar heat gain in summer. There should be good ventilation in summer and avoid cold winds in winter. The ideal orientation is very important for buildings in a region with short sunlight hours in winter. Generally, rectangular buildings with north-south orientation get more solar radiation in winter due to the changing pattern of solar altitude angle and azimuth angle. At the same time, the building group can reduce the solar radiation heat gain in summer, the main building group to avoid east-west sun exposure, is the most favorable building orientation.

II. A. 3) Environmental greening

The greening of the environment has three main roles for the optimization of the thermal environment of a building complex. One, because the natural subsurface with soil, vegetation or water as the main cover absorbs solar radiation during the daytime for heating the soil and plants, respectively. Most of the heat can be absorbed through transpiration and photosynthesis of plants [24], [25]. The direct link with the building occurs in the local environment around the building, i.e. its surrounding microclimate. Secondly, the use of trees and other plants can guide the wind direction. If the tree planting arrangement is appropriate, the airflow around the building can play a guiding or blocking role, so as to achieve the role of regulating wind speed and guiding wind direction. Thirdly, in the process of production activities, the building will produce carbon dioxide, carbon monoxide and other harmful gases. Through photosynthesis, green plants can partially consume these gases discharged from industrial production, thus purifying the air and ensuring people's respiratory health.

II. B.Building design for thermal environment optimization

II. B. 1) Size factor

Changes in building shape directly affect the size of building heating and air conditioning energy consumption. Therefore, the design of building shape should be as conducive as possible to energy conservation, and the specific design of the building shape coefficient through the control of the building to achieve the purpose of reducing the energy consumption of the building. Building form factor (S) refers to the ratio of the exterior area of the building in contact with the outdoor atmosphere (F) (excluding the area of the ground, unheated stairwell partitions and doors) to its enclosed volume (V), i.e.: $S = F/V$, the size of the building form factor has a very significant impact on the building's energy consumption [26]. Generally, the larger the form factor, the larger the area of the envelope that is subject to the outdoor cold and hot climate environment shared by the unit building space, and the greater the heating or air conditioning energy consumption.

II. B. 2) Window-to-wall ratio

Generally speaking, the thermal insulation performance of ordinary windows has a big gap compared with that of external walls. In the course of this research, it was found that most of the buildings in dense urban areas are using ordinary windows with poor heat preservation and insulation performance, which is the thermal weakness of the exterior envelope. Therefore, the ratio of window to wall becomes a very important part of ensuring the quality of the building thermal environment. The larger the area ratio of window and wall, the larger the building energy consumption. A region is located in the hot summer and cold winter area, in the summer daytime, the solar radiation entering the interior through the window will be much more than that entering through the exterior wall, thus further increasing the building's air-conditioning energy consumption in the summer. Therefore, in order to better ensure the quality of the indoor thermal environment of the building, on the basis of meeting the requirements of open windows for ventilation and lighting, the window-wall ratio can be designed to be smaller, which is of positive significance for improving the quality of the indoor thermal environment and reducing the energy consumption of the building at the same time.

II. B. 3) Natural ventilation

Through rational building design, natural ventilation can reduce indoor temperature, take away hot and humid gases, and remove dirty indoor air without consuming non-renewable energy. While meeting the thermal comfort requirements of the human body and providing clean natural fresh air, it achieves the purpose of building energy saving. The thermal stratification principle ventilation is shown in Figure 1. The key to the use of monsoon convection is the location of the window openings and the way they are opened, when the south wind direction, you can open the side windows below the south wall of the building, while opening the high side windows above the north wall, so that the airflow will enter from the lower side windows of the south wall, and upward across the interior of the building, carrying the indoor heat from the high side windows of the north wall into the outdoor environment, and vice versa.

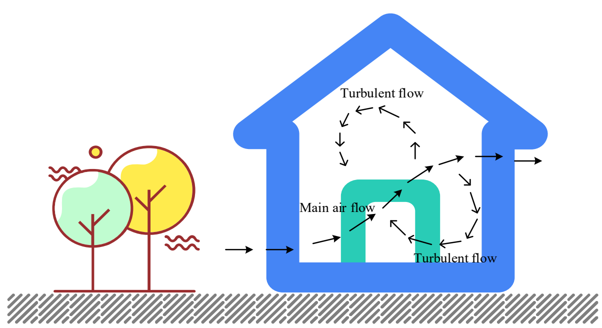


Figure 1: Natural ventilation using the principle of thermal stratification.

II. C. Exterior Envelope Design for Thermal Environment Optimization

In hot summer and warm winter regions, the design of building shading, insulation and ventilation is more important than thermal insulation, and the wall is the main enclosure of the building and the main channel for heat gain and loss. In one area, the exterior walls of the building remodeling commercial office building followed the wall materials of the original building with little change. As a result, brick walls are the main material of the building's envelope, with most using solid clay bricks and some using hollow bricks. Most of the brick walls are painted with light-colored paint on the outside, and a small number of them are left directly exposed. In terms of thermal performance, windows and doors are the weakest part of the exterior envelope. As far as thermal performance is concerned, the weakest part of the external wall is the external door and window. Gaps between glass and window frames and door frames, as well as gaps between doors and windows and walls, can lead to indoor heat loss, while outdoor heat and natural winds can also enter the interior, thus affecting the indoor thermal environment.

II. C. 1) Shading design

In this region, where the intensity of solar radiation is high, shading needs to be considered in conjunction with building facades and energy-saving measures, and passive shading methods can be used to reshape buildings.

The installation and use of sun shading devices need to be decided in conjunction with the form of the original exterior windows. Commonly used sun shading components include: sunshade louvers, shading cloth (curtains), sunshade panels, and sunshade canopies. First of all, sunshading devices can be divided into internal sunshade, external sunshade and center sunshade according to the location. Among them, external shading blocks most of the solar radiant heat while radiating it to the outdoor air, which has obvious advantages over intermediate and internal shading. Internal shading methods (blinds, sunshades) can only block a portion of the solar radiation, the infrared radiation contained in the sunlight hitting the windows heats up the glass, the visible and ultraviolet radiation raises the temperature of the shading material, and the temperature of the air between the internal shading and the windows increases, indirectly leading to an increase in indoor temperatures, which is highly undesirable as an indoor thermal environment in the summer. External shading significantly changes the image of the building, while internal shading has less impact on the original façade of the building. The materials of shading devices can then be categorized into soft shading and hard shading. Soft shading refers to traditional drapery fabrics and shades, while hard shading refers to metal blinds, wood blinds and roller shades. Hard shading is durable and capable of exterior styling, but is more expensive. Soft shading is flexible in form. Therefore, hard shading can be used on the exterior of the window, and soft shading is desirable on the interior. The south side needs to add the same comprehensive sunshade components with the north side, not only to achieve facade unity, but also to improve the internal thermal environment.

II. C. 2) Window design

The weakest part of the external wall is the external door and window. The gaps between the glass and window frames and door frames, as well as the gaps between the doors and windows and the walls, will lead to the loss of indoor heat. At the same time, outdoor heat and natural winds will also enter the room, thus affecting the indoor thermal environment. For glass heat transfer, there are three ways to improve the thermal performance of exterior windows: one is to add insulating film to the original window, the other is to replace the double-pane insulating glass, and the third is to add a second window. Double insulating glass mainly refers to vacuum double glass. As the vacuum layer in the middle cannot conduct heat, compared with ordinary double glazing, the structural principle of vacuum lamination is used between the two layers of glass. Vacuum double glazing glass has better thermal insulation performance. Generally, energy-saving glass, such as heat-reflective glass or Low-E glass, can be used as an insulating material. In order to save energy, the strategy used here is to apply an insulating film to the original glass, i.e., one or more layers of metal and gold oxide films are coated on the glass. These films have better control properties over optics, especially the reflection of infrared radiation in sunlight, better reflection and absorption of sunlight, greatly reducing the transfer of radiant energy from sunlight to the room, and maintaining a stable room temperature, thus achieving the purpose of energy saving.

II. C. 3) Roof design

The most common form of roofing for buildings is the flat roof, but also sloped and serrated roofs are used, and almost always without thermal insulation. Optimization of materials and forms of roofs is aimed at improving the thermal insulation of the roof. Green roofs are green spaces with soil cover on the roofs of various buildings and structures. In urban areas where outdoor space is in short supply, especially in relatively enclosed office spaces, green roofs are a solution to the conflict between proximity to nature and land constraints. Forms of green roofs can be categorized into light green roofs and heavy green roofs, depending on the desired roof load and configuration. Lightweight green roofs are often also referred to as green roofs. The main forms of green roofs used are light green roofs and heavy green roofs. The main technical characteristics of lightweight green roofs are: light weight, usually less than 120 kg/m. The thickness of the substrate is usually less than 20 cm. It is particularly suitable for old roofs with low load-bearing capacity. Plants are resistant to drought and barrenness, slow growth and rough management. Low construction and maintenance costs, usually less than 2/5 of heavy duty green roofs are easy to spread over large areas. Heavy-duty green roofs, mainly roof gardens, require high loads; therefore, the introduction of light-duty green roofs is suitable for roof retrofitting in the thermal environment of buildings.

Attention should be paid in the renovation: the equipment pipeline layer should be set in the ground or special layer, the roof should not be used as the equipment pipeline layer, the static and live load generated by the green roof should be minimized and a safety reserve should be left for the special case, and attention should be paid to the waterproof treatment of the roof when renewing it with green roof.

II. C. 4) Placement of water bodies

Thermal environment regulation of water body landscape system. The temperature and humidity of the environment are regulated by changes in the form of matter, such as absorbing heat from the surrounding air during evaporation and transpiration of a body of water to increase the humidity of the surrounding air, and releasing heat to the surrounding air during freezing and solidification of a body of water to increase the humidity of the surrounding air to a certain equilibrium point, and lowering it to a certain equilibrium point. The temperature and humidity of the environment are regulated by changes in the form of matter. Aquatic plants, planted in conjunction with waterside landscaping, have the ability to regulate the thermal environment. Therefore, adding a body of water between two buildings improves the thermal environment in the entrance and exit foyers. When the outdoor air flow rate increases, the wind passes through the water body to bring moist air into the building, making the indoor thermal environment of the building optimized and improved.

III. Evaluation of the effect of optimizing the thermal environment of building clusters

III. A. Analysis of planning and design effects

Building space is the carrier of building function, and reasonable space treatment can influence the indoor thermal environment of the building. Building space includes the orientation of the building, the functional layout of the building, the organization and order of different spaces in the building. Good building space design can not only bring convenience to life, but also improve the comfort of people living in the building. However, with the changes in production and life, people's concepts have begun to change, and the traditional building form can no longer meet the higher requirements of people's indoor comfort in the building. According to the above (2.1.1, 2.1.2, 2.1.3), it can be seen that the planning and design of thermal environment optimization of the building group mainly focuses on the three parts of the planning layout, orientation selection, and environmental greening, and this subsection focuses on exploring the relationship between the planning layout and thermal environment optimization.

III. A. 1) Description of evaluation indicators

The indoor thermal comfort of buildings with non-artificial heat and cold sources is generally evaluated by the APMV (Adaptive Mean Thermal Sensory Index) value, and the APMV for composite human thermal comfort takes the value of -1 ⩽ APMV ⩽ 1. However, due to the small range of the value of the APMV, coupled with the small change of the indoor APMV of the building when changing some of the building's attributes, it is not conducive to comparing the optimization methods. In order to evaluate the optimization method more objectively, this paper introduces two reference values of indoor temperature and humidity of the building in order to describe more intuitively the effect of the optimization method on the change of indoor thermal environment of the building. The evaluation criteria of APMV, indoor temperature and indoor humidity are as follows:

(1) APMV

When the value of APMV is -1 ⩽ APMV ⩽ 1, the evaluation standard of indoor thermal environment of the building reaches the second level or above, and more than 75% of the people express their satisfaction with the indoor thermal environment of the building, at which time people feel comfortable in the building. Therefore, this paper adopts -1 ⩽ APMVAPMV ⩽ 0.5 as the valuation index of APMV.

(2) Indoor temperature

There is no active system for heating in the building complex, and the indoor temperature of the building can reflect the performance of the building under natural conditions, i.e., the higher the indoor temperature, the better the building performance.

(3) Indoor humidity

Too high or too low indoor humidity in a building will affect the human body's thermal sensation. Keeping the indoor temperature of a building within the appropriate range is important for human thermal comfort, and there are no clear regulations for indoor humidity in buildings that do not use centralized heating.

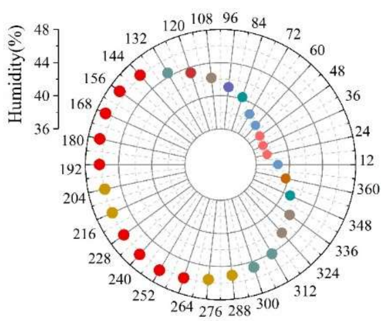
III. A. 2) Analysis of results

The building orientation simulation conditions are shown in Table 1, and the influence of building orientation changes on the comfort of the indoor thermal environment of the building will be investigated in order to determine a reasonable building orientation angle. In this paper, we choose the measured three-room and two-depth plan form self-built house B as the simulation object, and set the initial conditions of the model: the building orientation is due south, the ratio of both north and south windows and walls of the building is 40%, and the building plan and building envelope refer to the actual situation of the self-built house. By changing the orientation of the building, the indoor thermal environment simulation is carried out in the software for buildings with different orientations to get the corresponding indoor temperature, humidity, APMV.The building orientation of the model is simulated from 0°C to 360°C. In this paper, the building is rotated counterclockwise with 12° for the south direction, 90° for the east direction, 180° for the north direction, and 270° for the west direction, and the step of orientation change is 12°C, and a total of 30 working conditions are simulated.

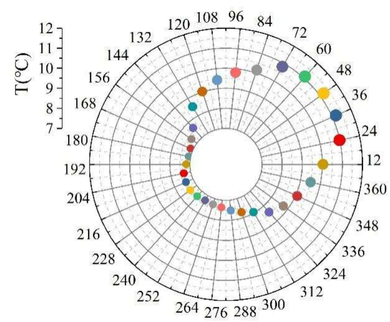
Table 1: The building faces the simulated condition

Condition number	Building Orientation (°)	Condition number	Building Orientation (°)
B1	12	B16	192
B2	24	B17	204
B3	36	B18	216
B4	48	B19	228
B5	60	B20	240
B6	72	B21	252
B7	84	B22	264
B8	96	B23	276
B9	108	B24	288
B10	120	B25	300
B11	132	B26	312
B12	144	B27	324
B13	156	B28	336
B14	168	B29	348
B15	180	B30	360

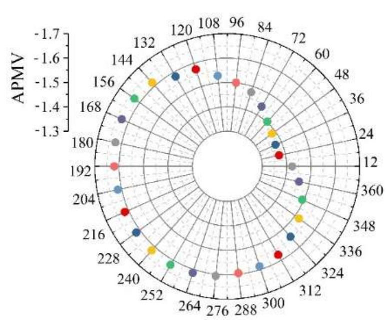
Figure 2 shows the relationship between building orientation and the average indoor temperature, humidity, and APMV of the main rooms of the building, where (a) to (c) indicate humidity, temperature, and APMV, respectively. It can be seen from Figure 2 that when the building direction changes from 12°, the indoor temperature and APMV of the building gradually increase, and the temperature and APMV value reach the maximum at 36° (36° south-east of the building), and the temperature of the main room increases by 0.53°C relative to the south, and then when the building orientation is increased, the indoor temperature and APMV slowly decrease, and finally decrease sequentially, until the indoor temperature and APMV reach the minimum value of about -1.62998 at 156° (24° north-east of the building). Throughout the building change, the main room average humidity changes in the opposite direction of the room temperature and APMV changes, but the building average indoor humidity varies in the range of 36% to 48% throughout the change.



(a)humidness



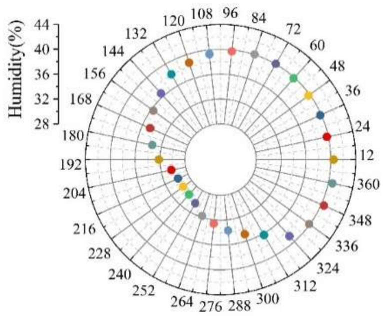
(b)temperature



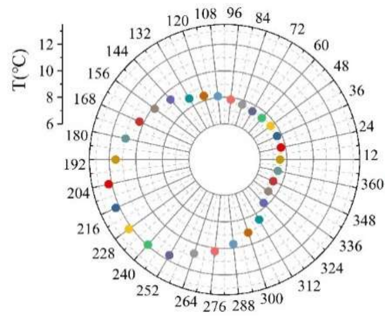
(c)APMV

Figure 2: Relationship between building orientation and building thermal environment

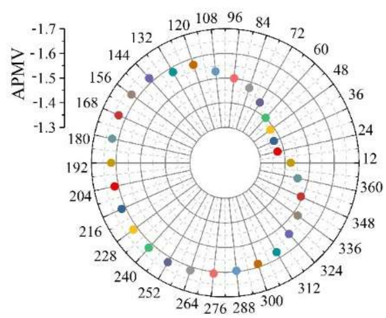
Figure 3 shows the relationship between building orientation and the average indoor temperature, humidity, and APMV of the building's secondary rooms, (a) to (c) are consistent with the above. It can be seen that the average indoor temperature and APMV of the secondary rooms of the building decrease first with the building orientation, and reach the minimum value at 36° (36° south east of the building), which is about 7.531°C, and then gradually increase, and reach the maximum value of the average indoor temperature and APMV when the building is oriented to 216° (36° north west of the building), when the indoor temperature is 12.21°C, and the APMV is - 1.69. After passing the high point, the indoor temperature and APMV of the building gradually decreased. Throughout the building changes, the average humidity change in the secondary rooms varied in 28% to 44%. The reason for the change is analyzed because the window-to-wall ratio of the local buildings in the north and south directions is almost the same, and the opening area of the windows in the north direction is larger, so when the secondary rooms originally located in the north direction face the south direction, a large amount of solar radiation shines into the room, heats up the indoor air, and raises the indoor temperature of the building, which makes the inhabitants feel more comfortable indoors in the winter time. Due to the change of solar radiation, the indoor humidity of the building changes.



(a)humidness



(b)temperature



(c)APMV

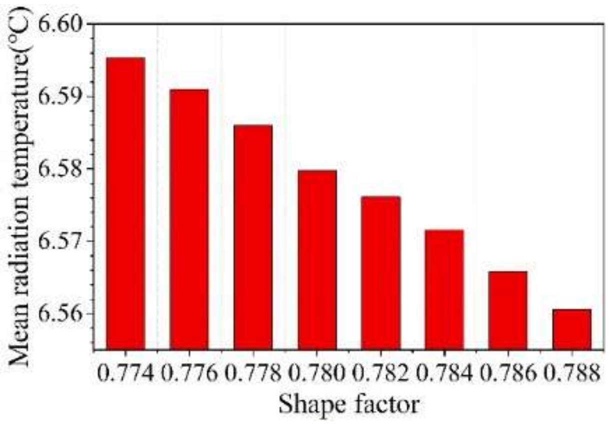
Figure 3: The relationship between building orientation and room thermal environment

III. B. Analysis of architectural design effects

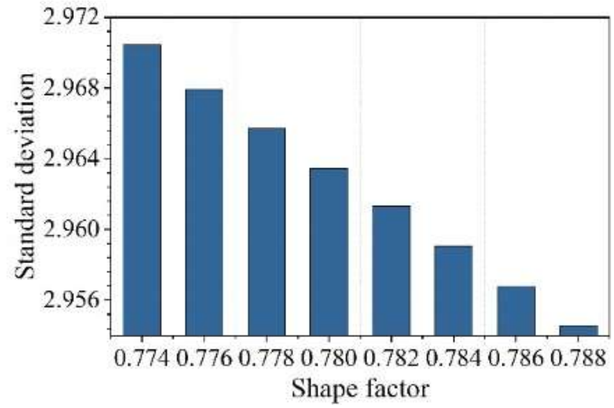
From subsection 2.2, it can be seen that the building design for thermal environment optimization revolves around the body shape factor, window-to-wall ratio, and natural ventilation, and this subsection focuses on exploring the relationship between the body shape factor and the design effect of thermal environment optimization, in which the thermal environment optimization indexes that are examined are temperature and humidity.

III. B. 1) Temperature simulation results

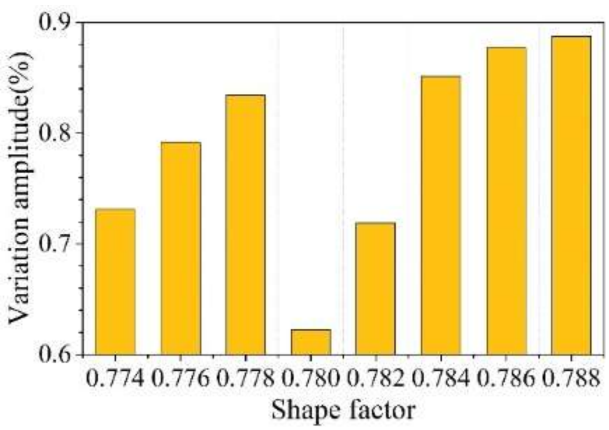
The simulation results of body shape coefficient and thermal environment temperature are shown in Fig. 4, where (a) to (d) are the average radiant temperature, standard deviation, magnitude of change, and maximum temperature, respectively. From the average radiant temperature graph, it can be seen that the average radiant temperature shows a decreasing trend with the increase of the body shape coefficient, and it can be seen that reducing the body shape coefficient can improve the indoor temperature. According to the standard deviation graph, it can be seen that the standard deviation value decreases with the increase of the body shape coefficient, i.e., increasing the body shape coefficient will improve the stability of the indoor temperature. From the magnitude of change graph, it is understood that when the body shape coefficient is increased from 0.786 to 0.788, the indoor temperature change is most pronounced and when the body shape coefficient is increased from 0.782 to 0.784, the indoor temperature change is least. Based on the maximum temperature graph it can be understood that it decreases with the increase in the body shape factor.



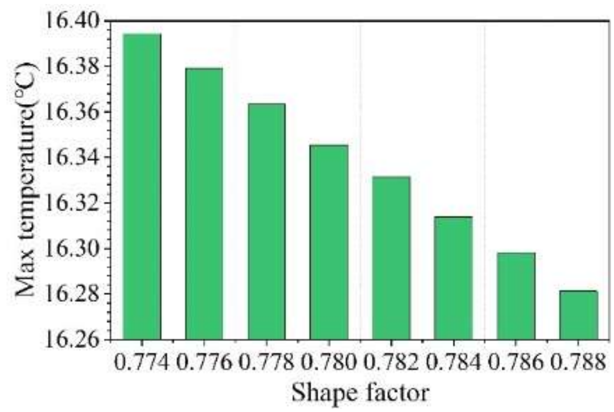
(a) Mean radiation temperature



(b) Standard deviation



(c) Variation amplitude

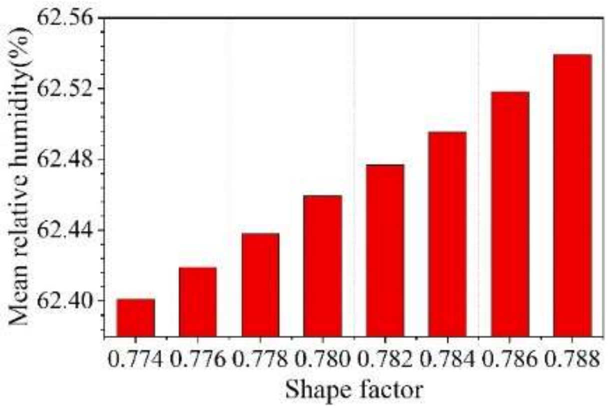


(d) Max temperature

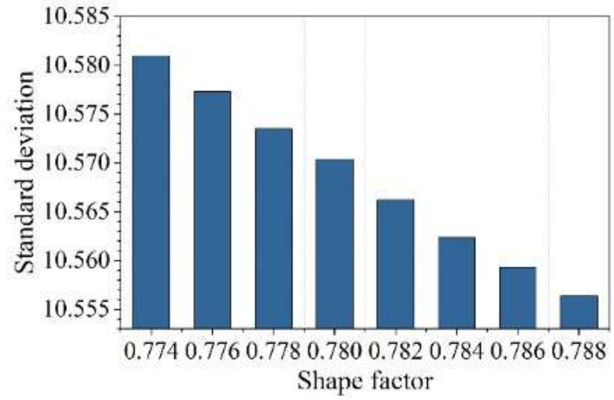
Figure 4: Temperature simulation

III. B. 2) Indoor humidity simulation results

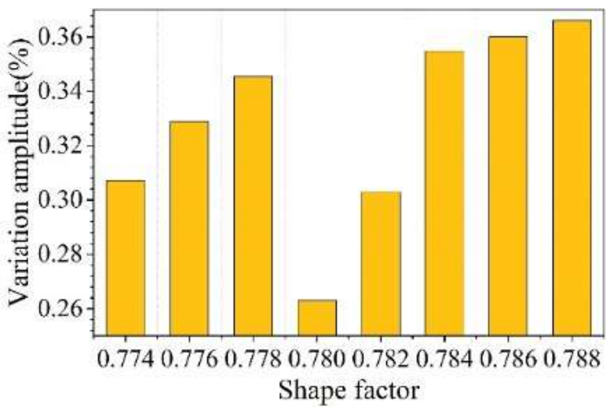
Figure 5 shows the simulation results of indoor humidity, where 5 (a) to (d) are the average radiant humidity, standard deviation, magnitude of change, and maximum humidity, respectively. From Fig. 5(a), it can be seen that the average relative humidity increases with the increase of body shape coefficient, which shows that when controlling the body shape coefficient of the residence by changing the length of the residence, decreasing the body shape coefficient can play a role in reducing the indoor humidity. According to Fig. 5(b), it can be seen that the standard deviation value decreases with the increase of the body shape coefficient, i.e., increasing the body shape coefficient can improve the stability of indoor humidity. According to Fig. 5(c), it can be understood that the indoor humidity changes most significantly when the body shape coefficient is increased from 0.786 to 0.788, and the indoor humidity changes least when the body shape coefficient is increased from 0.782 to 0.784. According to Fig. 5(d), it can be understood that it rises with the increase of the body shape factor.



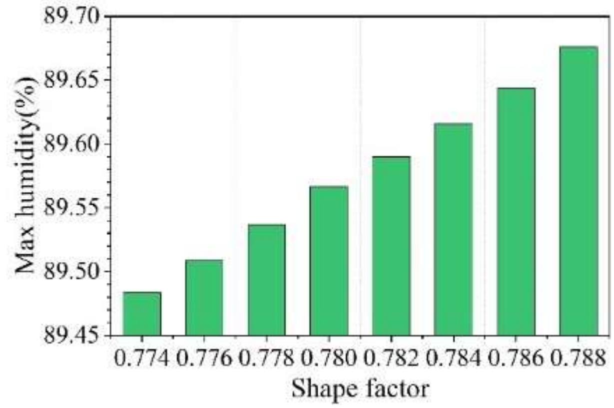
(a) Mean relative humidity



(b) Standard deviation



(c) Variation amplitude



(d) Maximum humidity

Figure 5: Indoor humidity simulation results

III. B. 3) Summarization

Through the above simulation analysis, it can be found that when the body shape coefficient is in the range of 0.774~0.788, the body shape coefficient has a greater degree of influence on the indoor temperature, and the stability of the indoor temperature is better until the stability is the best when it is about 0.788, so the range of the body shape coefficient from 0.774 to 0.788 is a better choice under this condition. In terms of indoor humidity, when the body shape coefficient is in the range of 0.774 to 0.788, it has a greater degree of influence on the indoor humidity, and therefore the range of body shape coefficients from 0.774 to 0.788 is a better choice under this condition.

III. C. Analysis of the effect of the design of the external enclosure structure

III. C. 1) Description of the envelope

Enclosure: JY rigid foam polyurethane composite heat preservation and decorative integration board exterior wall exterior insulation renovation, retaining the original color of the building appearance, the exterior windows are replaced with heat-breaking aluminum profile LOW-E hollow and high-transparent glass center-hung windows, the exterior windows of the south elevation are set up with horizontal sun shading panels, and the roofs are renovated with planted roofs, and meanwhile, the water body is added between the two buildings, to improve the thermal environment of the entrance/exit foyer.

III. C. 2) Comparison of natural temperature before and after optimization

Using DeST simulation software to simulate the optimization scheme of the building group, we now get the natural temperature distribution statistics of all rooms before and after the optimization of the building group, and the natural temperature comparison results before and after the optimization are shown in Table 2. According to the data performance in the table, it can be concluded that after optimization, the total number of hours in which the natural temperature of all rooms is 26~36℃ increased by 147002h, an increase of 26.78%, that is to say, the number of hours of natural temperature that is more comfortable throughout the year increased by 26.78%. The total number of hours throughout the year in which the natural temperature of all rooms was below 26°C decreased by 53,929h, a large amount of change, or a decrease of 14.04%. The total number of hours in which the natural temperature of all rooms was 36~47℃ and above 47℃ for the whole year decreased by 47,130h and 25,922h respectively, totaling 73,052h, with a total decrease of 14.92%. Overall, the effect of thermal environment optimization of the building complex is very obvious, with a significant increase in the number of hours of comfortable natural room temperature inside the building, a close reduction in the number of hours of low temperature and high temperature, and a comparable effect of thermal environment optimization in winter and summer.

Table 2: The natural temperature contrast results were optimized

Name	t<26℃	26℃≤t<36℃	36℃≤t<47℃	T≥47℃
Duration (h) (before optimization)	421277	514208	398551	64418
Duration (h) (after optimization)	367348	661295	351421	38496
Variation	-53929	147087	-47130	-25922
Proportion (before optimization)	30.12%	36.77%	28.50%	4.61%
Proportion (after optimization)	25.90%	46.62%	24.77%	2.71%
Rate of change	-14.04%	+26.78%	-13.08%	-41.09%

IV. Conclusion

This paper synthesizes the climatic and geographic conditions of an urban area, and optimizes the thermal environment of buildings in the density urban area in terms of planning, architectural design, and structure of the external enclosure in terms of energy saving of the buildings in the area. The simulation software is used to analyze the effect of the optimized design on the thermal environment of the buildings. The average indoor temperature and APMV reached the maximum value when the building was oriented at 216° (36° north west of the building), at which time the indoor temperature was 12.21°C and the APMV was -1.69. After passing the high point, the indoor temperature and APMV of the building gradually declined, which was mainly due to the fact that a large amount of solar radiation increased the indoor temperature of the building. For both indoor temperature and humidity, the range of body shape coefficient from 0.774 to 0.788 is a better choice, and when the body shape coefficient is 0.788, both temperature and humidity values are optimized. The total number of hours in which the natural temperature of all rooms is 26~36°C after optimization increases by 147002h, which is 26.78%, i.e., the number of hours with more comfortable natural temperature increases by 26.78% throughout the year. In conclusion, the practical effect of the optimized design scheme for the thermal environment of the building group proposed in this paper is very significant.

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