Design intervention process and intervention strategy of “Constant-holistic Shadow” space in hot summer area

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Abstract: It is one of the goals of outdoor space design in hot summer areas to construct a “constant-holistic shadow” space for outdoor people that can always be in the shadow during the required period of time in summer. However, the relevance and process of design elements related to the space of “constant-holistic shadow” are different from those of conventional design, as well as methods, stages and objectives of design intervention. Therefore, it should be controlled according to appropriate stage design objectives and contents. Based on the relationship between the design goal and the design process of “constant-holistic shadow” space, this paper analyzed the feasibility of the design process intervention under the construction goal of “constant-holistic shadow” space and clarified the corresponding design intervention process and strategies. It is expected to provide green design ideas and methods for promoting the utilization efficiency of summer shadow and optimizing the thermal comfort of outdoor public space in summer hot areas, as well as enrich the relevant theories and methods of outdoor public space design.

1. Introduction

As the main place for outdoor activities, the outside needs to pay more attention to its spatial quality and applicability. In hot summer areas, outdoor activity places should not only meet the general convenience, accessibility and applicability, but also meet the requirements of photothermal comfort, which should be effectively addressed in relevant planning and architectural design.

Relevant researchers have made a preliminary exploration on the design solutions of sunlight and shadow in outdoor built space [1]. For example, based on the improvement of outdoor thermal comfort and building energy consumption, the urban design theory and method of sunshine adaptability are constructed, and the influence of sunshine on urban environmental quality is comprehensively analyzed from the overall perspective [2]. Relevant simulation was carried out to explore the optimal layout of buildings in the urban grid based on the requirement of sunshine to avoid excessive shadow [3]. Research on the generation method of architectural form was oriented by environmental lements based on shadow analysis [4]. Based on the WBGT index, relevant concepts such as effective shadow area and ineffective shadow area and effective shadow area for thermal regulation were proposed to study the ecological design method of the external space of commercial pedestrian street [5].

Studies have shown that shadow space can effectively reduce the temperature of outdoor space, but the spatial and temporal dynamics of shadow space make its shape, orientation, length and shadow depth constantly change. As a result, the shadow space is difficult to adapt to people's requirements of
relatively fixed space and complete shadow process in outdoor activities. To a large extent, it restricts the thermal comfort and activity convenience of outdoor public space activities in summer. In recent years, the study found that the buildings, structures, such as plant structure formed by the shadow body within a certain range, and in a specific period of time continue to complete the whole shadow space in the sunshine outdoor conditions (figure 1), the criterion can go through a destination in a specific period of time, space for activities to build a fixed them suitable range of complete shadow space, so as to improve the thermal comfort and activity convenience of the crowd during the summer outdoor activities. At the same time, the construction of “constant-holistic shadow” space can only be realized by combining the forming mechanism with construction goal of “constant-holistic shadow”, and also intervening in the conventional planning and design stage in an appropriate process and way. However, there is still a lack of exploration on the appropriate design process and method aiming at the construction of “constant-holistic shadow”. Therefore, by sorting out the phased goals and work contents of conventional outdoor public space and centering on the construction goal of “constant-holistic shadow” space, this paper elaborates the feasibility of design intervention as well as the design process and main strategies of how to intervene in the conventional design process.

2. Conventional design process and “Constant-holistic Shadow” space design

2.1. Conventional design process

Conventional design process depends on urban planning, architectural design, landscape design and other aspects in the process of urban construction. The urban planning stage includes the overall urban planning, the zoning planning, the controlling detailed planning and the construction detailed planning. The architectural design process is on the basis of urban planning orderly program design, preliminary design and construction drawing design. According to the requirements of the planning at the higher level, the design is implemented in the four stages of construction detailed planning and design, site design, architectural design and environmental detail design for the design of outdoor public space.

In the planning and design stage, the overall conception and planning design of the construction project must be made. First of all, it is necessary to understand the planning requirements of urban planning for the project land, and master the natural conditions of the construction project, including climate, terrain, surrounding environment and other elements. Secondly, the spatial organization and landscape characteristics are determined according to the construction objectives, and the planning and layout of buildings, roads and green space system within the scope of the land is defined.

In the stage of site design, it is necessary to clarify the requirements of the site general plan and the vertical design of the site and establish the basic relationship of various elements in the site. The specific performance is to determine the specific location of buildings and structures in the site, as
well as the layout of traffic flow lines of roads, parking lots and squares in the site, and to determine the planting methods and layout of plants. In the architectural design stage, it is necessary to determine the height and shape of the building, divide the internal functions of the building and its streamline, and perfect the design of the horizontal section of the building. The emphasis of outdoor space in the architectural design stage lies in the topological relationship between architecture and outdoor space environment.

In the stage of environmental detail design, the details of site design and architectural design should be extended and expanded. We need to consider the color matching of various elements in the site, humanized design and barrier-free design, as well as the selection of plant species and hard paving materials.

2.2. The influence of the space goal of “Constant-holistic Shadow” on the design process

The construction of “constant-holistic shadow” space is an additional goal of outdoor public space design on the basis of the conventional design goal. Therefore, in the design, attention should be paid to the influence of related design elements involved in the construction goal of “constant-holistic shadow” space on the design process, while not hindering the effective realization of other design goals.

The design under the construction goal of “constant-holistic shadow” space should focus on the factors that have influence on the shadow range and quality of its space. The shadow forming range and quality of “constant-holistic shadow” space are mainly related to geographical location, time and date, shape conditions and terrain. The construction conditions include the spatial layout, shape, height, orientation and the material of the construction surface.

The dynamic spatiotemporal relationship of shadows should be considered in the design process of “constant-holistic shadow” space construction. The altitude angle and azimuth angle of the sun vary with geographical location, time and date. The shadow forming range of “constant-holistic shadow” space also changes accordingly (Figure 2). The vertical fluctuation of the terrain and the different slope and aspect can significantly affect the spatial attributes such as the size and orientation of “constant-holistic shadow” space. The primary consideration in the design process under the space goal of “constant-holistic shadow” is the geographical location of the project and the time period in which there is a need for “constant-holistic shadow”. According to the changing law of the sun of altitude angle and azimuth angle, the terrain with elevation difference is properly treated.

The design criteria under the goal of “constant-holistic shadow” space construction have been increased at each design stage. On the premise of meeting the basic design target standards and norms, the layout of the shadow body should be adjusted according to the spatial and temporal requirements of the “constant-holistic shadow” space in the planning and layout stage, so as to achieve the optimal shadow forming range of “constant-holistic shadow” space. In the stage of scheme design, the influence of the shape, height and orientation of the structure on the size and shape of “constant-holistic shadow” space should be considered, among which the influence of the structure is the most significant. Priority should be given to the shape, height and orientation of the architectural facets. The design combines the elements of the architectural image with the structure and plant image. In the detailed design stage, attention should be paid to the processing of details, such as the permeability and reflectivity of the material of the image surface, the leaf density of the plant image surface and so on, which affect the quality of the space of “constant-holistic shadow”.

Fig. 2 Spatial range of “constant-holistic shadow” at 10:00-12:00 on the summer solstice in different areas

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The design process under the goal of “constant-holistic shadow” space construction must add design technology link. The construction mechanism of “constant-holistic shadow” space is an exploration of the law of the correlation between the internal elements of the construction body and the shadow. However, the shape, size, orientation, shadow depth and length of the “constant-holistic shadow” space are all related to its construction mechanism. Under the construction goal of “constant-holistic shadow” space, each design stage must simulate and analyze the shadowing results and the spatio-emporal variation process of its design elements, and also carry out design tests on the integrity and suitability of the expected “constant-holistic shadow” space at relevant planning and design levels.

2.3. Feasibility of space design intervention of “Constant-holistic Shadow”

The construction of “constant-holistic shadow” space has influence on the conventional design process, but these influences do not prevent the reasonable realization of other design goals. From the point of view of design process, the goal achievement degree of “constant-holistic shadow” space in each design stage is consistent with the conventional design process, and its design goal can be realized gradually by relying on the conventional design process. In terms of the processing of design elements of “constant-holistic shadow” space, different design stages can properly deal with the influencing elements of “constant-holistic shadow” space on the premise of meeting the standard requirements and go into the design and construction of “constant-holistic shadow” space in an orderly way. It is specifically reflected in the following points. In the stage of planning and design, the nature of land can be determined according to urban planning requirements. And the spatial and temporal demands of “constant-holistic shadow” for outdoor activities of people can be analyzed with big data. On the premise of meeting the basic planning requirements, the layout of buildings, the road system and the green space system can be adjusted according to the “constant-holistic shadow” construction mechanism. The outdoor public space can establish the basic relationship of all elements in the site and determine the basic form of all elements in the site with the construction goal of “constant-holistic shadow”. In the architectural design stage, the height of the building shape can be adjusted appropriately under the premise of meeting the winter sunshine. In the design stage of environmental details, the intervention of the construction goal of “constant-holistic shadow” space can make the design elements of outdoor space more hierarchical and high-quality.

3. Design intervention process under the space goal of “Constant-holistic Shadow”

3.1. The construction of the design intervention process

The design process under the goal of “constant-holistic shadow” space construction is consistent with the conventional outdoor design process, which is from the whole to the part, from the general to the detailed. However, there are some subtle changes in the local area that need to be fine-tuned in the design process. For example, the needs and types of crowd activities are the service objects for the construction of “constant-holistic shadow” space. In the early stage of planning and design, the spatial attributes of the activity site and the temporal and spatial needs of crowd activities for the “constant-holistic shadow” space should be grasped. As the main shadow of the “constant-holistic shadow” space, the height of the building can be considered in the site design stage to facilitate the shadow space design of structures and plants. Based on the characteristics of the influence of the construction goal of the “constant-holistic shadow” space on the design process, the design process of the “constant-holistic shadow” space is considered without hindering the realization of other design goals, as shown in figure 3.
3.2. Objectives and work contents of the relevant design phase

3.2.1. Planning and design stage
In the stage of planning and design, the design goal of “constant-holistic shadow” space is mainly to determine the layout and size of each shadow element of “constant-holistic shadow” space. Firstly, it is necessary to understand the nature of the project land and the type of users. Different site types have different spatial and temporal distribution of crowd activities, and different crowd types also have different spatial and temporal demands for “constant-holistic shadow” space. It is necessary to specifically analyze the time period with demand “constant-holistic shadow” space and the shading layout mode based on activity type. Secondly, it is important to understand the topographic changes of the project land, simulate the impact of the three topographic factors of flat land, sloping land and platform on the “constant-holistic shadow” space and properly deal with it. Finally, the layout of buildings, road systems and landscape systems within the scope of the land is carried out according to the needs of people and the construction mechanism of “constant-holistic shadow”. In this stage, the layout of each system should choose an optimal solution of “constant-holistic shadow” construction layout on the premise of meeting project requirements and specifications.

3.2.2. Site design stage
In the stage of site design, the goal of “constant-holistic shadow” space design is mainly the adaptive design of the shadow body. Outdoor public space is mainly composed of square, street and park. In the site design stage, the main structure should be determined according to the functional type of the site. For example, the activity space around the building is mainly based on the architectural structure, the square is mainly based on the master shadow, and the park and open street are mainly based on the main shadow of plants. On this basis, it is necessary to determine the shape, height and orientation of the building structure, as well as the layout of plants and the configuration design of plants, shrubs and trees according to the shape, size and shadow depth required by the “constant-holistic shadow”.

3.2.3. Architecture (landscape) scheme design stage
In the stage of architectural design, the goal of “constant-holistic shadow” space design is to perfect the lack of shadow and complement of shadow. In the stage of architectural design, it is necessary to consider whether there is a lack of shadow in the building. The main reason for the lack of shadows may be related to the overhead layer and the corner of the building. The shape of the building can be adjusted appropriately according to the specific lack of shadows. If the lack of shadows cannot be satisfied, the adaptive design of shadows should be considered for structures and plants.

3.2.4. Detailed design stage of architecture (landscape)
In the design stage of environmental detail, the goal of the space design of “constant-holistic shadow” is mainly to optimize the shadow quality of the space. In this stage, the main consideration is the
selection of the material of the construction structure, plant species and the material of the bearing surface pavement. The extensive use of film materials and glass will lead to the phenomenon of light transmission, so that the shadow depth of the “constant-holistic shadow” becomes shallow. The selection of material with high reflectivity on the exterior wall surface will also affect the “constant-holistic shadow” space, so it is necessary to choose the appropriate material for the exterior facade of the shadow. Leaf density, crown shape, crown width, crown height and under-branch height of plants all affect the quality of “constant-holistic shadow”. If the leaf density of plants is small and the under-branch height is too high, it cannot form a good “constant-holistic shadow” space. The thermal conductivity of different pavement materials on the ground is different, and the range of temperature change is also different. Therefore, if the thermal comfort in the “constant-holistic shadow” area is better, the pavement material with small thermal conductivity such as grass, board and floor tile should be selected.

4. Design intervention strategy of “Constant-holistic Shadow” space

4.1. Hierarchical and orderly intervention according to the design method in the design stage
The design of outdoor public space under the goal of “constant-holistic shadow” is an additional goal on the basis of the conventional design process. The design intervention should adopt a hierarchical design strategy and follow the conventional design process to achieve it step by step, first as a whole and then as a part, step by step. From the structure of the layout, the layout of road landscape system of large space layout is related to the field of traffic flow and the height of body shape and so on various design elements of processing which are required to clear all levels of build focus and build target, to ensure that “constant-holistic shadow” space build integrity and scientific.

4.2. In line with the design depth of each stage
The design stage under the construction goal of “constant-holistic shadow” must be combined with the working depth of the conventional design stage to ensure that it does not hinder the realization of the goal of the conventional design in each stage, and at the same time achieve the design depth under the construction goal of “constant-holistic shadow”. For example, the layout of the elements of the “constant-holistic shadow” should be determined in the planning and design stage, and at the same time, the large scale missing architectural shadow should be considered. The adaptive design of each structure of the “constant-holistic shadow” must be completed before the end of the scheme design stage. In the detailed design stage, it is necessary to optimize the construction elements that affect the quality of the space of “constant-holistic shadow”.

4.3. Early control of overall target elements
The emphasis of outdoor space design under the space goal of “constant-holistic shadow” is different from that of conventional design, so the factors related to the overall situation should be taken into consideration. For example, human's space-time demand for “constant-holistic shadow” is the fundamental purpose of the space construction of “constant-holistic shadow”, which should be regarded as the starting point of design intervention and the core reference of subsequent adaptive adjustment in each design stage. The shadowing mechanism of “constant-holistic shadow” space is different in different terrain, so topographic elements must be considered in the early stage of design. As the main structure of the “constant-holistic shadow” space, the shape of the building is more regular than that of structures and plants, which can meet the needs of most types of activities. Therefore, the form and layout of the building should be involved in the design as soon as possible.

5. Conclusion
The “constant-holistic shadow” space can meet the needs of people's outdoor activities in summer for full-time shading. It can be designed through the conventional design process under the guidance of the goal, but it needs to make appropriate changes and expansion in the design content, method, stage
goal and other aspects. The specific design elements mainly include geographical location, vertical conditions of the site, and the morphological characteristics of the silhouette, etc. The design elements and standards that need to be considered in different design stages are different. The design intervention strategy of “constant-holistic shadow” space can be adopted, which is layered and orderly intervention according to the design stage, consistent with the design work depth of each stage, and early control of the overall objective elements. This paper mainly discussed the feasibility of the design intervention based on the general design process of “constant-holistic shadow” space design, and clarified the content, process and strategy of the intervention, and the relevant intervention design methods need to be further explored in the future.

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