

Preliminary Research on Parametric Design of Plant Landscapes

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Abstract With the continuous development of computer and information technology in the new era, more and more industries have entered the digital era, and parameterization has been widely applied in many industries. However, there is little systematic research on parameterization and plant landscape design. Based on the application of parametric design in various industries, this paper analyzes and obtains enlightenment, puts forward the idea of parametric design of plant landscapes, constructs the logical relationship between parametric design and plant landscape design, organizes the design process, and conceives the operation mode and the theoretical model. This study preliminarily explores the combination model of parameterization and plant landscape design, popularizes the feasibility and promotes the industry to gain more understanding and research on parametric design of plant landscapes. To give full play to the advantages of parametric design is not to pursue design automation, but to take it as an auxiliary tool for plant landscape design, as a way of inspection and review; to improve the efficiency and scientificity of plant landscape design, and to promote the further development of landscape architecture.

Keywords Landscape architecture, Parameterization, Plant, Conception

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Parametric design refers to parametric control or an important property of the design result. The design result will be changed if the parameter values change. Xu Weiguo believed that the key links in the design process are: datalization of design requirements information, establishment of design parameter relations, establishment of parameter model of computer software and so on^[1]. The results of relevant information can be quickly summarized and deduced by computer, and displayed in the form of visual data, which greatly broadened the possibility of design. In this study, based on the practical application of parameterization in related fields, the idea of parametric design of plant landscape was conceived and the way of parametric design of plant landscape was explored.

1 The definition and enlightenment of parameterization

1.1 Parameterization

“Parameterization” is a question in the fields of mathematics, statistics, and computer science. The combination of “parameterization” and “design” can be roughly divided into two categories: “parametric aided design” and “parametric design”. Professor Xu Weiguo thought that parametric design in the field of architecture in essence is to find a relationship or rule and organize the main factors affecting the design. Specifically, factors affecting the design can be taken as the variables or parameters, the

parameter model can be formed and described by computer language, the parameters and variable data information can be converted into images by computer technology, and the result is the prototype of the design^[2].

1.2 The enlightenment of parametric application to plant landscape design

The application of parametric design in landscape architecture is at the initial stage. In the process of landscape planning, it is not only required that individual landscape elements are generated by certain rules, but also that each landscape element is correlated with each other^[9], which involves a wide range and has many impact factors, making it difficult to consider comprehensively. Design research mainly focuses on the results of landscape parameter extraction and design rules, such as: rules of plant community location, research of landscape patch, component principle of landscape texture, research of water system form, research of landscape facility ergonomics and so on^[3].

1.2.1 Current situation and problems of plant landscape design. The relationship between plant landscape design and parameterization has not been studied in depth with the development of digital age. The selection and application of plants in the process of plant landscape design are the basis for the construction of plant landscape. For the selection and application of plants, the author summarizes as the three types: the type of growth habit, the type of landscape effect and the type

of ecological function. As a basis, the type of growth habit ensures that plants can survive and grow healthily when applied to the site. The type of landscape effect creates different plant space, color change, hierarchical distribution, feature construction and other perceptual experience for plants. The type of ecological function is to meet the needs of ecological environment, improve ecological efficiency and promote the healthy development of human settlements. However, in the process of practice, the selection of plant species can be roughly divided into two types. The one is to get familiar with plant species and habits through accumulated practical experience. The other is to query plant characteristics through the books and the Internet, which the process is time-consuming and laborious. In the construction of plant space, the designer has a strong sense of subjective guidance and ignores the local environmental factors and the current situation of the site^[10]. As a result, the plant landscape design lacks the scientificity and rationality, which hinders practical operation and future construction.

1.2.2 The enlightenment of application in related fields to plant landscape. This study uses the experience of the application of parametric design in the relevant field for reference, combines with the practice of parametric design in landscape architecture planning and design, such as some great impact factors in landscape architecture: the proportion of hard landscape, the proportion of water, greening coverage,

carrying capacity in space and so on. And the study also uses the statistical methods such as hierarchical classification analysis and principal component analysis, the frequency distribution analysis^[4] to get the data of relevant index which can be used to guide the value range of the parameters. Get the revelation, the elements of plant landscape design such as the growth rate of plant, the shape of ground line, the changes of skyline, the degree of perspective are highly consistent with parameterized application. From the point to the surface, the elements of plant

landscape design are transformed to the impact factors. And the study explores the relationships between the elements, and constructs the logic relationship by using parametric thinking. The author finds that the industry of plant landscape design is in urgent need of the combination of parametric ideas which has a huge development space, by literature review and project practice. And there is also in a need to explore the application of parametric design, conceive parametric design, thinking and application methods, so as to drive the trend of parametric

design in the whole landscape architecture industries and improve the scientificity and efficiency of landscape architecture.

2 Preliminary research on parametric design of plant landscapes

2.1 The conception of parametric design of plant landscapes

With the help of the accuracy of the computer information technology, the high efficiency, the intuition of parametric design and the characteristic of the scientific summary and the rational analysis, the designer considers comprehensively the statistical query of the mass data^[5] and the analysis demand which the plant landscape application needs such as soil types, climate suitability, the collocation of seasonal color, the changes of spatial volume, the changes of physiological property and the ecological benefits, corresponding to the relationship between site parameters and plant parameters (Fig.1). The designer applies the parametric design to plant landscape design, combines with excellent design results and typical plant landscape models, analyzes and summarizes the relationships among plant landscape elements in the excellent design^[6], and finds their universality and particularity, transforms them into the parameters of plane language and the quantitative indicators. The designer also needs to build a parametric model based on the type of growth habit, determine the weight ratio of the type of landscape effect to the type of ecological function according to the design requirements, site conditions and construct the different parametric models according to the different weight ratios of each type of impact factor. At the early stage of design, the parameter model is determined by the site conditions and design requirements, and the corresponding algorithm is run to generate more scientific and reasonable proposals.

2.2 The parametric design idea of plant landscape

The parametric design of plant landscape should first clarify the categories of impact factors that need to be analyzed in the design, which are divided into three types: growth habit, landscape effect and ecological function. Secondly, a comprehensive analysis of multiple factors should be conducted based on the impact factor level, and the factors affecting the basic growth and development of plants should be screened to further narrow the application range of plant species, and then the optimal plant species should be planned and laid out. In the phase of planning the layout,

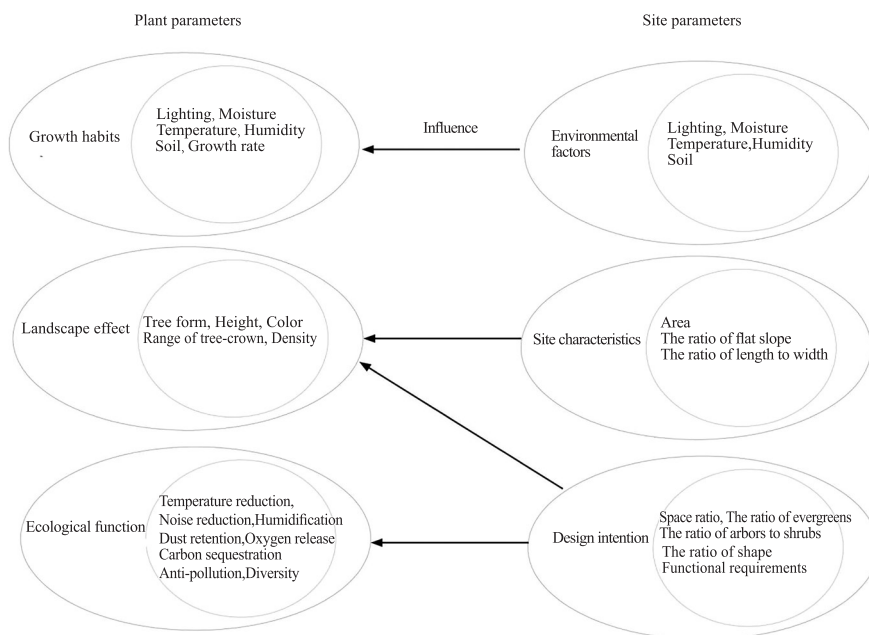


Fig.1 Relationship between plant parameters and site parameters

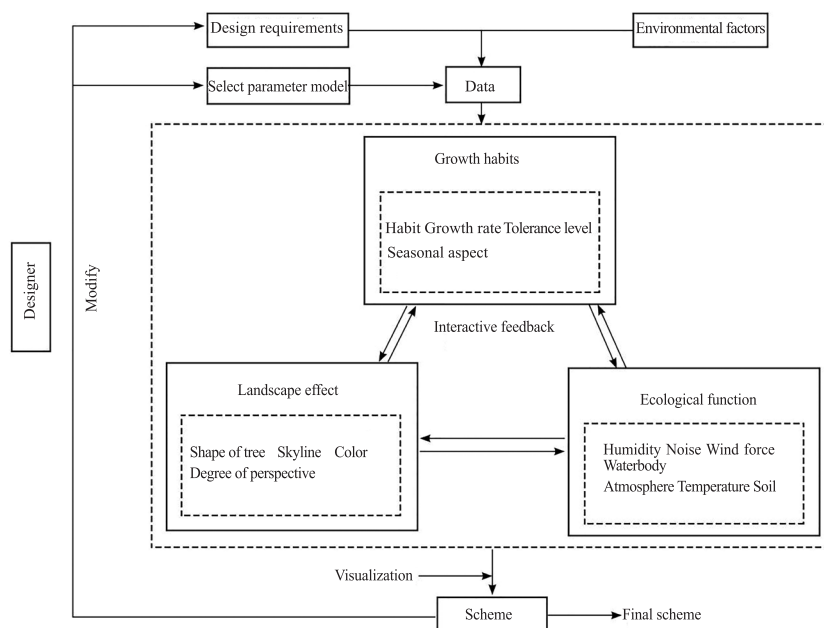


Fig.2 Parametric design flow of plant landscapes

the designer determines the different parameter models according to the integrated positioning of site conditions and design requirements. After the interactive feedback among growth habit, landscape effect and ecological function, the designer provides one or several suggested schemes according to different weight ratios of parametric models, and performs the visual analysis. After comparative study by designers, the scheme is determined after optimization (Fig.2).

In short, the parametric design process is “design elements—impact factors—factor datalization”^[7]. Through the analysis process of factor datalization and rational selection of plant species, designers can monitor the whole process and modify parametric variables to control plant planning and layout, quantify the changing rules and predict the future development. It is established under three types of interactive feedback influence mechanism, so as to ensure the accurate control of plant landscape design, avoid the time wasted by tedious search and comparison, improve the accuracy, the scientificity of plant landscape design and the efficiency of work.

3 The conception of plant landscape design parameters setting

Parametric design is not only a formal feature that affects recent design, but also

a new paradigm to create design thinking^[8]. Parametric design is a thinking method in a logical way of describing relationships, which requires the establishment of a complete plant database platform to integrate and conclude the elements of soil, climate, seasonal color and physiological cycle of plants. Plant landscape design parameters can be divided into two categories: site parameters and plant parameters. Site parameters are obtained through investigation and reference, which are mainly divided into three types: environmental factors, site characteristics and design intention. Plant parameters can be divided into three types: growth habit, landscape effect and ecological function. Site parameters affect the value and change of plant parameters. In the design process, the designer needs to consider the impact factors. By modifying the parameter of the impact factor, the expected effect is formed and the preliminary design scheme is obtained.

A case study of landscape design of plants on both sides of river, the basic situation of the site is obtained firstly through the status quo of both sides of the river, including the climatic zone of the site, the local environment and climate, the growth situation of plant inside the site, the slope of revetment and so on. Then, the designer determines the design theme according to the current situation analysis and the main parameters which divided into plant community,

plant space and plant seasons according to the idea of theme. The following is an example of specific parameters, which shows the situation of setting, debugging and screening of plant configuration.

The plant communities on both sides of the river should be mainly green to achieve shade, and mainly adopt arbors and shade tolerant plants^[11]. The ratio of evergreen to deciduous is set as 7 : 3, and the range of tree height is 8–15 m. The tree is in the shape of ovate, and the tree type is the large arbors and ground cover. The preliminary scheme configuration diagram is formed according to parameter setting (Fig.4–6). The side near water mainly adopts the form of open forest cover to remain the perspective line, while some parts of the road side are planted in a high density to prevent people from entering and serve as the background of forest.

According to the landscape effect after the adjustment of parameter variables, the tree species should be set with high branch point and large shade, and the tree species with steep shape should be added to further obtain the collocation type of tree species. For example, the community composition schemes are selected by calculation and constitute the main plant landscape features on both sides of river, such as the composition of *Pterocarya stenoptera* + *Sapium sebiferum* + *Taxodium distichum*—*ophiopogon*, and the composition



Fig.3 The front view of plant configuration



Fig.4 The side elevation of plant configuration

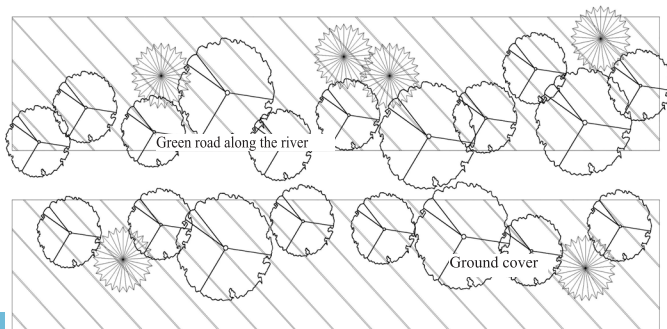


Fig.5 The planar graph of plant configuration



Fig.6 The front view of plant configuration



Fig.7 The side elevation of plant configuration

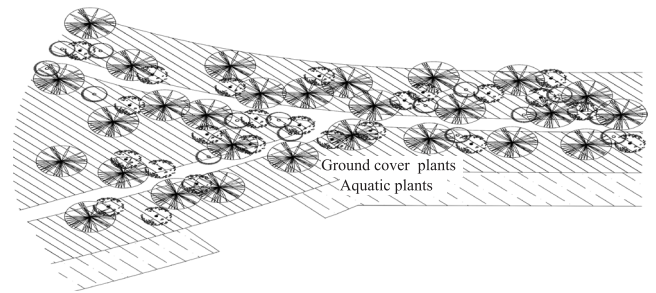


Fig.8 The planar graph of plant configuration

of *Metasequoia glyptostroboides* + *Taxodium distichum* + *Ulmus parvifolia*—*ophiopogon*.

The layered plant structure is arranged in a specific node area, and the initial parameter is also set. The ratio of evergreen and deciduous is 4 : 6, the range of tree height is 2–15 m, the tree shape needs not set, and the community type is arbors + shrub + the layered structure of groundcover, form the preliminary map of plant configuration (Fig.7–9). Generally, it is arranged in the delicate nodes of landscape such as the start of bridge, platform and building, which also plays a role of isolation. Tree species can be combined in a variety of ways, such as the community of *Metasequoia glyptostroboides* + *Taxodium distichum*—*Armeniaca mume*—*Iris wilsonii*, and the community of *Cinnamomum comphora* + *Koelreuteria bipinnata*—*Lagerstroemia indica* + *Punica granatum*—*ophiopogon*.

4 Conclusions and prospects

Parametric technology advances in constant practice and exploration, and future data can serve as a medium which is based on information technology, combine with the historical cultural background of the site to definite the aesthetic logic, seek rules in the dynamic, and create a more ideal design. Parametric design cannot replace design by designers, because it cannot be equipped with human's ability to perceive the environment, nor can it solve all social problems. Besides, parametric design is not the automation of design, but a kind of scientific standardization, a way of inspection and review, which helps to provide basis for analyzing information and developing ideas.

This study aims at getting enlightenment from the application progress of parametric design in landscape architecture. The construction and design process of parametric design system for plant landscape design is discussed preliminary, and the examples of the application in parametric design of plants is described and prospected. However, no parametric model is established in this study. Then, the interactive feedback relationships of three types will be elaborated including namely, the type of growth habit, the type of landscape effect and the type of ecological function. And the weights of the type of landscape effect and the type of ecological function are assigned respectively to provide an algorithm for the parameter model. When the preliminary pattern of parametric design of plant landscape is conceived, the designer will take it as a point to expand. The purpose of this study is to save the time of searching for plant species in the process of plant landscape design, focus more on analyzing of scene and thinking of design, improve the scientificity and rationality of plant species selection. More people are expected to participate in the establishment of a perfect database and software platform for parametric design of plants, so as to conduct more scientific and efficient plant landscape design and promote the progress of landscape architecture industry.

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