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# Research on Park Theme Design Based on the Integration of User Needs and Environment

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## ABSTRACT

This study focuses on the field of park chair design, aiming to explore effective ways to organically integrate the diverse needs of users with the environment, and create park chairs with high comfort, rich functions and excellent aesthetic value. Through in-depth research on relevant theories, precise numerical modeling, rigorous experimental verification and comprehensive result analysis, the core elements and innovative strategies of design are clarified. The research results provide theoretical support and practical guidance for optimizing the design quality of park chairs and improving the user experience of public spaces, promoting the construction of urban public facilities, and satisfying people's pursuit of a better life (Ma & Wang, 2014).

## THEORETICAL METHODS

### Ergonomic Theory

Ergonomics is crucial to the design of park seats. In-depth research on human body size, range of joint motion, muscle mechanics, etc. provides a scientific basis for seat design. The seat height is usually set at 40-45 cm, which is conducive to the user's feet landing steadily, relaxing leg muscles and reducing leg pressure; the seat surface depth is 40-45 cm. Too deep or too shallow is not conducive to body support. The backrest height is 30-40 cm, tilted back 10-15 degrees, fitting the human spine curve and relieving back muscle tension; the armrest is located 20-25 cm above the seat surface and 5-8 cm wide, which is convenient for placing arms, assisting in getting up or changing sitting posture, and enhancing stability and security (Pang, Chen, & Lyu, 2017).

### Material selection theory

Material selection affects the performance of park seats. High-quality antiseptic wood has natural texture and warm touch, which can blend into the natural landscape of the park, but it needs regular maintenance. Stainless steel and aluminum alloy are strong, corrosion-resistant, easy to clean, and modern in shape, suitable for modern style parks, but they are easy to absorb heat in summer and need insulation or heat dissipation measures. Plastic materials are colorful, light and cheap, and new high-performance plastics have good weather resistance. Wood-plastic composites combine wood texture and plastic durability, which is an ideal choice for balancing performance and cost. (Chen, 2015)

| Material | advantage | shortcoming | Applicable scenarios |
|---|---|---|---|
| wood | Natural texture, warm touch, high integration | Vulnerable to natural environment, requires regular | A park that pursues a natural |

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| | | | |
|---|---|---|---|
| | with natural landscape | maintenance | style |
| Stainless steel | High strength, corrosion resistance, easy to clean, modern design | High initial cost, easy to absorb heat in summer | Parks with sufficient budgets and seeking long-term stable use |
| Aluminum alloy | High strength, corrosion resistance, light weight | higher cost | Parks with seat weight requirements |
| plastic | Rich colors, light weight and low price, some high-performance plastics have good weather resistance | Some plastics have poor durability | Parks with limited budgets and low requirements for the life of seats |

**Theory of Aesthetics and Environmental Integration**

Aesthetics and environmental integration is the core of park seat design. The design can draw on natural forms, such as simulating the curves of petals and leaves to add natural vitality; it can also use simple geometric shapes to create a modern and simple style. The color matching should be coordinated with the overall tone of the park. Natural landscape parks are suitable for natural colors, and modern urban parks can use bright colors appropriately. The decorative patterns on the surface of the seats can tap into local cultural elements, spread culture, enhance the cultural connotation and artistic atmosphere of the park, and trigger emotional resonance among users (Lee & Chen, n.d.).

**Demand for park chairs in different ages and regions**

Demands of different age groups: Children are lively and active, and are sensitive to colors and shapes. They need park chairs with bright colors and interesting shapes, preferably with cartoon characters or amusement functions, such as seats designed in the shape of animals with small slides or climbing frames, so that they can play and rest. The seat height should be suitable for children's body shape, avoiding inconvenience and danger caused by being too high or too low. Teenagers are full of energy and like socializing and outdoor activities. They hope that there is enough space around the park chairs for sports such as skateboarding and roller skating, or for communication and gathering with friends. The seats can be designed in a modular style to facilitate flexible layout adjustment. In addition, they are equipped with technological facilities such as charging ports and wireless networks to meet their needs for using electronic devices. Adults tend to relax or do short work in parks. They need a comfortable and quiet resting environment. The design of the seats should be ergonomic, provide good waist and back support, and relieve physical fatigue. For adults who need to work, sunshade and rainproof facilities and lighting equipment can be set up near the park chairs for use in different weather and time periods. The elderly have declining physical functions and are relatively inconvenient to move, so they have higher requirements for the safety and comfort of park chairs. The seat height should be moderate, convenient for getting up and sitting down, generally 42-45 cm is more appropriate; the armrests should be sturdy and of appropriate height, usually 30-35 cm is ideal, and anti-slip materials can be used to increase friction and facilitate grip. In addition, the seat should have good stability to avoid shaking or tipping.

Demands of people in different regions: In cold areas, the temperature is low in winter, and the material of park chairs must have good cold resistance to prevent brittle damage due to low temperature. Cold-resistant metal materials or seats with added warm materials can be selected. At the same time, in order to reduce the discomfort of people touching cold seats in cold weather, removable warm cushions can be designed. In hot areas, park chairs should focus on sunshade and heat dissipation functions. Large parasols or awnings can be

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set up, and the seat materials should be made of materials with poor thermal conductivity, or ventilation designs can be adopted, such as setting air holes on the surface of the seat to help air circulation and reduce the surface temperature of the seat. In coastal areas, the air humidity is high and contains salt, which is highly corrosive to park chairs. Therefore, seats should be made of corrosion-resistant materials, such as stainless steel, wood with special anti-corrosion treatment, etc., and regular maintenance should be carried out to extend the service life. In areas with profound cultural heritage, the design of park chairs should incorporate local cultural elements. For example, in historical and cultural cities, seats can draw on the shapes and decorative patterns of traditional buildings, such as carving ancient architectural patterns with local characteristics, folk story scenes, etc., making them a carrier of cultural inheritance and display, and enhancing people's sense of identity and belonging to regional culture.

**Numerical Modeling**

Use CAD, SolidWorks and other software to build a high-precision numerical model of the park seat, set the material properties, geometric dimensions and connection methods of the seat components, and simulate the stress conditions in different usage scenarios, such as the force of users sitting and standing up and outdoor wind and snow loads. Use finite element analysis to calculate the stress and strain distribution, determine the structural weaknesses, optimize the design, and ensure the strength and stability of the seat. At the same time, use CFD software to simulate airflow and heat exchange, analyze the surface temperature distribution and ventilation and heat dissipation effects of the seat, adjust the material and structural design details, and improve thermal comfort (Zhang & Du, 2023).

**Experiment User comfort experiment**

Recruit volunteers of different ages, genders, physical conditions, and from different urban and rural areas to participate in the experiment to ensure sample diversity and representativeness. The experiment was conducted in a laboratory simulating a park environment or in an actual park. Let the user sit on the designed seat prototype, and use pressure sensor cushions, motion capture systems, heart rate monitors and other equipment to record data such as sitting time, pressure changes in various parts of the body, posture adjustment frequency and amplitude, and heart rate fluctuations. (Tao & Chen, 2016)

At the same time, a subjective comfort questionnaire was distributed, covering the overall comfort of the seat, the support effect of the backrest and armrests, the softness and breathability of the seat surface, etc. Users are encouraged to share their feelings and suggestions for improvement. After statistical analysis of the experimental data, the seat comfort is comprehensively evaluated, the influencing factors are found, and the direction for design optimization is provided.

Different age groups have obvious differences in their demand for seat comfort. Due to the decline of physical functions, the elderly pay more attention to the stability of the seat and the height of the armrests, and expect the armrests to help them get up; children prefer seats with bright colors and interesting shapes. In terms of urban and rural differences, urban residents have a fast pace of life and may prefer simple and modern style seats; rural residents are affected by the natural environment and are more receptive to seats with natural elements.

**Durability test**

Prepare multiple park chair samples and formulate durability test plans based on actual use environment conditions and industry standards. Place the samples in outdoor venues in different climate zones to simulate long-term natural environmental impacts. Regularly use material performance testing equipment to detect changes in the mechanical and chemical properties of the samples, check the appearance and structural

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integrity, and build a complete durability evaluation system. Through long-term tracking and monitoring, understand the aging and damage laws of materials and structures, provide data support for material selection and structural design, and ensure long-term and stable use of seats outdoors. (Wang, 2020)

**Environmental integration experiment**

Select various types of parks and place the designed seats in different landscape nodes and functional areas. Invite professional landscape designers, park managers and ordinary tourists to form an evaluation team to evaluate the integration effect of seats and the environment from the dimensions of visual coordination, spatial adaptability and cultural fit. Take a large number of high-definition photos and videos, and use image analysis software to quantify and analyze indicators such as color contrast and shape similarity. At the same time, collect user feedback through on-site interviews and online questionnaires, and the comprehensive evaluation results provide a basis for optimizing seat design and promoting harmonious coexistence between seats and park environment (Richo, Rizky, & Pemandani, 2022).

## RESULT ANALYSIS

**Comfort Analysis**

Park chairs designed based on ergonomics can effectively relieve user fatigue and improve comfort. The backrest curve fits the human spine and disperses back pressure; the armrest height and width are appropriate, which is convenient for arm placement and force, and reduces the discomfort caused by body shaking and improper force. The softness and breathability of the seat surface material are closely related to the user's long-term sitting comfort, providing a reference for the selection and optimization of the seat surface material, helping to improve the user experience. (Li & Zhang, 2018)

Studies have shown that the elderly are more dependent on armrests when using chairs. Armrests of appropriate height and width can significantly reduce the difficulty of getting up for the elderly. A study on the use of park chairs by the elderly found that when the armrest height was 30-35 cm, the elderly were easier to get up and the risk of falling was reduced. This further verifies the importance of considering the special needs of the elderly in chair design.

**Durability Analysis**

Material selection and structural design rationality determine the service life of outdoor park seats. Selecting corrosion-resistant and weather-resistant materials, combined with scientific and reasonable structural design, such as strengthening key stress-bearing areas, optimizing drainage structures, and avoiding stress concentration, can enable seats to maintain performance and structural integrity for a long time in harsh natural environments. Comparative experiments show that optimized seats are more durable than unoptimized ordinary material seats, providing a practical basis for the selection and design of park seats, reducing maintenance costs and extending service life.

**Environmental Integration Analysis**

Seats that are coordinated with the park environment in terms of shape, color and material texture can improve the quality of park landscape and achieve organic integration. In historical and cultural parks, seats that incorporate traditional architectural elements and cultural symbols can inherit culture; in modern urban parks, fashionable and colorful seats highlight the vitality of the city. Public feedback is consistent with professional evaluations, indicating that seats with a high degree of integration can enhance the public's satisfaction and

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sense of belonging to the park environment, promote interaction between people and nature, and provide reference for park landscape planning and seat design (Kek & Selimin, 2023).

**Comparison and gap with international research**

European and American park seat design standards Germany has strict requirements on barrier-free seat design. There are obvious signs around the seats and the ground slope is regulated to facilitate wheelchair users. The UK pays attention to the coordination between seats and surrounding vegetation, and the materials tend to be degradable or recyclable. The North American NRPA standard requires that park seats have a variety of sizes and styles to meet the needs of different groups of people. Canada emphasizes the applicability of seats in cold climates and requires cold-resistant materials.

**The gap between this study and other studies and remedial measures**

This study has made a breakthrough in inclusive design by investigating the needs of marginalized groups. For elderly and disabled users, the armrest height is increased, anti-slip materials are used, seat height is adjusted, wheelchair space is reserved and signs are set up to meet the needs of special groups. In terms of sustainability, it not only focuses on the environmental properties of materials, but also studies their performance in different environments, comprehensively considers the life cycle cost, and provides a more comprehensive consideration for the long-term sustainable development of park seats, making up for the lack of international research. (Zheng, Li & Xu, 2017)

**Experimental Description**

**Schematic diagram of pressure sensor experiment**

The schematic diagram of pressure sensor experiment shows the distribution principle of pressure sensors on seats. Multiple pressure sensors are evenly distributed on the seat surface, backrest and armrest area, and are connected to data acquisition equipment. When the user sits on the seat, the sensor senses the pressure in real time, converts it into an electrical signal and transmits it to the acquisition equipment, generates pressure distribution data, and presents it in the form of a chart to help researchers analyze the impact of seat design on human comfort.

**Prototype images**

The initial sketch shows the preliminary design ideas of the seat, including the overall shape, approximate size and component layout. The shape is inspired by natural elements and the estimated values of key dimensions are marked. The 3D printed model is refined based on the sketch, presenting the three-dimensional shape and detailed structure of the seat more intuitively, which is convenient for researchers to observe and evaluate, and timely discover and adjust design problems, such as the angle between the armrest and the seat surface.

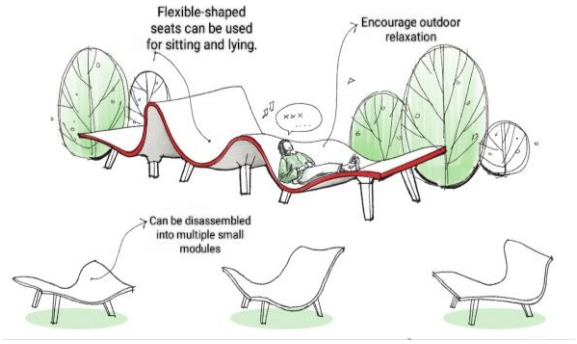


Figure 1: Prototype image

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## Survey of Marginalized Groups and Inclusive Design Suggestions

### Survey Process of Marginalized Groups

A combination of stratified sampling and random sampling was used to survey the elderly and disabled users. Questionnaires were distributed and interviewed to the elderly in community activity centers and elderly apartments, and online and offline surveys were conducted on disabled users in cooperation with the local Disabled Persons' Federation. The survey covered aspects such as seat usage habits, comfort perception, functional needs, and mobility difficulties. The survey found that the elderly had difficulty getting up and hoped that the armrests would provide stronger support; disabled users reported that the seat height did not match the wheelchair, making it inconvenient to get on and off the wheelchair.

### Inclusive design suggestions

Based on the survey results, inclusive design suggestions are proposed. Increase the armrest height to 30-35 cm, use anti-slip material, and widen it to 8-10 cm; adjust the seat height to 42-45 cm to accommodate wheelchairs; reserve at least 1.5m x 1.5m of flat space and set up barrier-free passage signs; set up Braille signs for the visually impaired and equip the hearing-impaired with induction devices to enhance seat inclusiveness.

## Comparison of material life cycle costs

### Calculation of various material costs

Take common materials as an example to calculate the material cost of park seats. The initial purchase cost of wood is 1,500-2,000 yuan per cubic meter, the annual maintenance cost is high, and the service life is 5-8 years; the initial cost of stainless steel is high, 8,000-10,000 yuan per cubic meter, but the maintenance cost is low, and the service life is 15-20 years; the price of aluminum alloy is 6,000-8,000 yuan per cubic meter, the maintenance cost is low, and the service life is 15-20 years; the initial cost of plastic is 3,000-5,000 yuan per cubic meter, some high-performance plastics are easy to maintain, and the service life is 8-12 years; the price of wood-plastic composite materials is 4,000-6,000 yuan per cubic meter, the maintenance cost is low, and the service life is 10-15 years.

### Cost comparison and decision-making suggestions

According to the calculation results, when the park budget is limited and the service life is not high, the cost advantage of plastic seats is obvious; for parks that pursue long-term stable use and have sufficient budget, stainless steel seats have low long-term costs; wood-plastic composite materials balance cost and performance and are suitable for parks that have requirements for beauty and environmental protection and have a moderate budget; although wood has high maintenance costs and a short service life, it still has application value in parks that pursue natural style and short-term use. Park managers can choose appropriate materials according to actual conditions.

## Specific product applications and quantification of environmental impact Specific product applications - solar chair

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The designed solar chair is equipped with a USB charging port, the top solar panel has a conversion efficiency of 20% - 25%, covers an area of about 0.5 square meters, can generate 10 - 15 watts of electricity per hour, and stores electricity in 5000 - 8000 mAh lithium batteries. It outputs stable voltage and current through the USB port and is compatible with common electronic devices. The seat adopts a lightweight and high-strength aluminum alloy frame and an environmentally friendly and weather-resistant plastic surface, optimizes the angle and position of the solar panel, and improves energy efficiency.

**Quantification of environmental impact - Material carbon footprint**

Quantify the carbon footprint of different materials to assess environmental impact. Wood absorbs carbon dioxide during growth, and emits carbon dioxide during processing and transportation, with a net absorption of about 1-1.5 tons/cubic meter; stainless steel and aluminum alloy production have high energy consumption and large carbon emissions, but high recycling rates; plastic production relies on petrochemical resources, has high carbon emissions, and some are difficult to degrade; wood-plastic composite materials have a moderate carbon footprint, and some components are recyclable. When designing and selecting materials, priority should be given to low-carbon footprint and recyclable materials, optimizing production processes, reducing carbon emissions, and promoting the sustainable development of park seats.

## CONCLUSION

This study focuses on the integration of user needs and the environment to carry out park chair design. Through theoretical research, numerical simulation, experimental verification and result analysis, practical design methods and innovative strategies are obtained. In practical applications, ergonomic concepts should be integrated, material performance, cost and environmental adaptability should be comprehensively considered, and attention should be paid to the integration with the park environment in culture, aesthetics and function. In the future, the application of intelligent materials, environmentally friendly renewable materials and cutting-edge technologies will promote the construction of urban public environment, improve the quality of public space facilities and urban leisure functions.

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