

Research on the design of small interior space

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Abstract. In such a high population density society as China, especially in developed cities, the real estate market needs a concept of micro-housing. Working people in big cities like Beijing and Shanghai spend very little time at home while working and socializing outside the home every day. High-density population cities need to meet the living needs of as many people as possible in a limited area. If we can solve this problem the demand for houses will decrease and prices will fall. And tiny buildings can also reduce greenhouse gas emissions. (Statistics show that residential, commercial, and industrial buildings account for 40 percent of greenhouse gas emissions.) The ecological benefits of micro buildings extend beyond the house itself. Micro buildings not only increase the density of housing, so that more people have a home, but also shorten the time of transportation. After consulting a large number of literatures, this study hopes to summarize the existing literatures and find the best way for micro buildings to meet the needs of more people in high-density population cities. In this study, conclude some interior design methods or techniques to find out how to improve the quality of small space design. We search and review information in three different fields: indoor thermal comfort, human-based furniture, and interior lighting design. The paper presents some techniques including thermal control equipment and a day-light prediction system. Different human-based furniture is divided into various types, we analyse their advantages and disadvantages, leading to the small interior space to find how can they be used to improve human's feeling. We discuss the possibility that designers enhance people's life in a big city by using indoor designing ways.

1 Introduction

Cities are the main places for people to live and work. With population increasing, the density of population is increasing in cities too. People share limited space of cities, which means lots of people can just have small interior space for their living or working. Micro buildings cater to this point that the future buildings should emphasize the increase of function rather than expanding size. However, small interior spaces easily let people have negative feelings like oppression and uncomfortable. Moreover, small indoor places usually call problems about air quality, bad lighting conditions, and so on. Research on buildings' interior space shows that poor air quality brings toxins, contamination, and poor ventilation to interior space, which will cause lots of physical health complaints. There are also lots of side effects of mental health, stress, and burnout [1]. At today, lots of new technologies, new analysis, and research are improving the design in small interior spaces.

The ideal micro buildings imagined in this study are economical, high-performance, convenient, with basic life functions and an area of less than 70m². Micro building can be single or can be a group of many single units. Generally, there is no special living room. The basic

function includes three parts, bedroom, kitchen, and toilet. The basic functions include three parts: bedroom, kitchen, and toilet. Micro buildings occupy very little area and space, and new technology makes such houses more functional. A good interior design is also needed to be a rethink at the view of small space and high population cities. Our research aims to review how to design a human-based comfortable small interior space in different fields like lighting, thermal comfort, and furniture. Good interior design can bring positive effects to people's life and health and also express designers' humanistic care to societies.

2 Methodology

To present recent developments and advance designing methods about interior space, a systematic review of literatures on interior design and factors which can influence interior comfortable is made. The study and information are combined with different cities' conditions about people's living. Then we think about how these interiors designing ways can influence people's lives in a city. Scientific reports, articles, and manuals were collected from Web of Science and CNKI. A combination of terminologies was used to improve the efficiency of the search strategy on a particular topic. We download and

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find articles based on our topic or some pioneer ways about interior designing. The data and information about cities are found in articles and some websites which have certification of local government. We identify the articles satisfying the following criteria: First, the application of thermal control in interior space and people's feelings. Second, human-based furniture design, especially the implication in small space. Third, the lighting controlling in interior space and the relationship between lighting conditions and people's feelings. We use programs to show different research results.

3 Micro building indoor environment suitable for human habitation

The indoor environmental conditions of the micro building that affect the comfort of the building environment are thermal, visual, and lighting design [2]. This research discusses interior space design through these three aspects. Literatures in these aspects are summarized and the thinking of these advanced designing is presented.

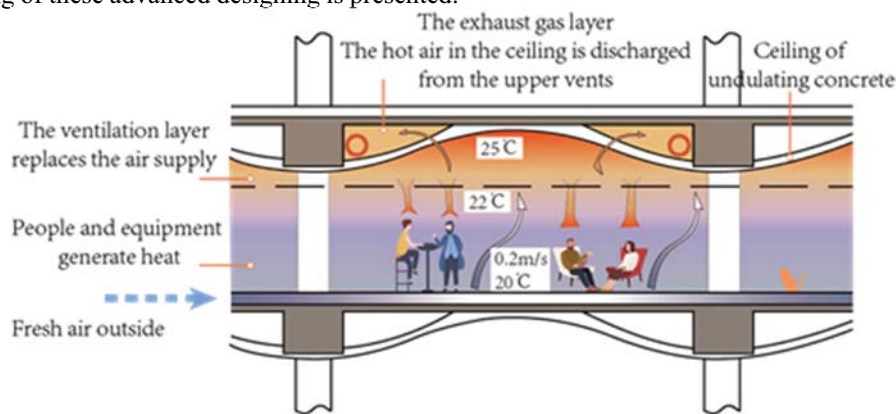


Figure 1. The interior design of thermal comfort.

On this basis, we conclude that micro buildings have more variability than ordinary buildings. Micro buildings have greater temperature fluctuations because they are more susceptible to seasonal and outdoor temperature variations. However, if the indoor environment is properly laid out, micro buildings will be flexible in dealing with the adverse effects of these external factors [6]. This research has investigated solutions to indoor thermal environment anomalies in many articles and practical cases. One approach to solve this problem involves the use of wavy roof ceilings. The advantage of this is that the hot air can be well directed upward and out of the room. An alternative approach to the problem is the use of concrete walls with air interlayers and insulation layers. The air interlayers and insulation layer allow the indoor and outdoor temperatures to be relatively independent. This prevents the indoor temperature from rising as the outdoor temperature rises. Also, if it is cold outside, the air interlayers and insulation layer can keep the indoor temperature stable.

3.2 Human-based furniture

When designing micro buildings, architects should also

3.1 The indoor thermal comfort

Thermal comfort is “that condition of mind which expresses satisfaction with the thermal environment” [3]. In ordinary buildings, the indoor thermal environment has little influence on the thermal comfort of the human body. Indoor airflow in micro buildings will be affected by envelope structure and indoor furniture display, resulting in indoor temperature change, and the hot air flow process will be amplified to affect the thermal comfort of the human body. In addition, since the walls, objects, human bodies, and other surfaces in miniature buildings are closer to each other, the scope of thermal radiation will be different from that of ordinary buildings, thus exerting an effect on the thermal comfort of the human body [4]. In the case of the same thermal power, when the space size decreases, the indoor air volume decreases, and the average temperature will rise. So, the smaller the building space, the more conducive to winter room warmth. But it can have a negative effect in the summer [5].


consider the types of people who will use them. Because be fond of using furniture in the light of different crowd, the room needs to reserve the space of furniture. The existing form of furniture in small space interior design has a stretch type, fold type, axial turn type, and hanging type [7]. The stretching type is usually the horizontal stretching type. It can be retracted into the wall or other furniture without taking up space when it not in use. Folding type and axial turn type will maximize the utilization of interior space and maximize the role of furniture itself. Hanging type is the method that seeks to find a place for furniture in vertical space. Take advantage of space that is usually barely used at the lift [7]. The home space of the micro building should be utilized as much as possible behind the door and inside the wall. In this way, it can make the use function of miniature buildings more abundant, while not affecting the user's activity space.

The axial turn type furniture is more suitable for young occupants. In this way, more young people can live and meet their daily needs. Furniture of the hanging type is not suitable for old people, because their active scopes are limited and they are not suitable for picking up items in the upper space. The group of people who use residential space can be classified. Micro space adaptation should not

be limited to single youth. However, after the division of groups, people of different ages, genders, and jobs have completely different lifestyles. Therefore, the micro-space

should also have the nature of individualization after satisfying the universality.

Table 1. The relationship between stretch type, fold type, axial turn type, and hanging type

The furniture existence form	The image display	Advantage	Disadvantage	Relationship with micro building
stretch type		①more space for use; ②does not take up space when hidden	sliding tracks are easily damaged	①increased use space and area;
fold type		①maximize the utilization of interior space; ②maximize the role of furniture itself	furniture corners are not easy to clean	②the utilization rate of irregular room area can be maximized
axial turn type				
hanging type		use the upper part of the room	not convenient to pick up clothes	

3.3 Interior lighting design

Lighting design is an important issue for sustainable buildings, which involves setting natural and artificial lights and meeting energy distribution goals. This process requires accurate lighting simulations, which are known to be computationally expensive for a single model and may become prohibitive when directly exploring lighting configurations for several sources [8]. Today's indoor lighting condition almost depends on daylighting and electric lighting. However, electric power is produced by burning fossil fuels, which will cause ecological problems and air pollution [9]. Especially in a city, lots of office buildings that use electric lighting as their main lighting system will cost numerous energies. In fully air-conditioned office buildings, electric lighting accounts for 20%-30% of the total electricity use and 10% for the residential sector [10]. Nature light is a more economical and natural friendly means. It makes to energy conservation in buildings. According to measurements on commercial buildings using daylight-link light control, this daylight system can help people to save 30%-60% of total electric lighting consumption [11].

Daylighting can save energy and realize the demand

for interior illuminance and be positive for people's mental health. Most of the time, people reach and feel daylight through the window, which means daylight also brings outside view to people at indoor space [12]. People today usually work in an indoor place. From our perspective, indoor space just like a box that encases people. The daylight can bring views, natural light, and even a warm feeling to people, obscuring the boundary of outside and inside [13]. (Some people also describe daylight as a kind of energy, of course, light truly has energy). If using more daylight as the main lighting system in indoor places, we believe more energy will be saved, and people will have more positive attitudes and energy.

However, according to these questions, indoor lighting should be controlled and designed using electric light and daylight. People can use photoelectric lighting controls to control the relationship between electric lighting and daylight in buildings [14].

Photoelectric lighting controls are a system that can automatically switch lighting on and off as the daylight levels go down and rise through a predetermined level. People can use computers to predict the condition of daylight. The systems named differential switching, time delay, and solar reset prevent frequently switching of light during unstable weather conditions when daylight levels

are fluctuating around the switching illuminance [11]. In this way, people can accomplish using more daylight and less electric light without influencing the need for indoor lighting levels.

4 Feasibility study

Today's cities suffer from energy waste, air pollution, and people's disease, including mental and physical problems. We think this advanced indoor design can help cities to prevent or solve some problems. For example, a thermal control system helps a building automatically control its air temperature, which means people do not need to keep opening air conditioners to maintain indoor temperature. A lot of energy would be saved. The lighting design also has a similar function. It reduces the use of electric light and lets more natural light come into interior space. It is plausible that thermal comfort design and lighting design can have deep effects on working buildings. Working buildings usually have lots of energy consumption due to air conditioners and electric lighting. A good indoor design about thermal control and lighting will these working buildings save numerous energies, which means cities also do not need to produce so much fossil energy and reduce the production of pollution. Moreover, the lighting design can also be used at every kind of building like apartments, schools, hospitals, etc. Nature light will bring more energy and positive effects to human's mental and physical health. Human-based furniture is also very meaningful for human's life quality, especially for people who live in a small room. Furniture with good design can help people save space, and lots of them have already concerned human-based specialize. The house price is truly expensive in cities (compared with the countryside), so that it is meaningful for people if they can even save one square meter by these furniture. We also know that lots of diseases are due to long time sit. The works like computer engineers or architects usually need to sit on the seat for a long time. Human-based furniture can help them maintain physical health. These human-based furniture indeed brings more comfortable feelings to people, which can help them have a good spirit condition when working. Human-based furniture can also improve people's life quality. When people go home after a busy day, they can relax on a human-based bed or sofa.

On the other way, cities that have good interior design also show designers' humanistic care for people and society. Designers care about the function and pioneer shape or idea of the building and cities and care about whether people have happiness and health in cities. A city or a building should show human care to people rather than only care about function, area, money. This is insurance that people want to make efforts and work for their cities, which means cities can keep their vigor and energy of development.

5 Conclusion

In this research, the analysis of the indoor thermal comfort of micro buildings, the design of human-based furniture, and interior lighting design help the space users achieve

comfortable user experiences. According to the living needs of different residents, the indoor environment with a reasonable space layout suitable for people to live is created under the condition of minimum building area. One approach to solve this problem is to change the form of the house's ceiling, so as to realize the indoor thermal cycle because the indoor thermal environment of micro buildings is easily affected by interior decorations. Designing appropriate position of doors and windows is also crucial for letting furniture can be put in ideal place. The ratio of kitchen and bathroom's area should also be adjusted to a desired number.

An alternative approach to the problem is to increase indoor activity space. This is achieved by using the spare space of the interior to assemble different types of folding furniture. Different user groups use different types of human-based furniture to expand their indoor space area. At the same time, the Photoelectric Lighting Controls System can be used to reduce the energy consumption and pollution caused by artificial light. This method maximizes the conversion of light energy by increasing the amount of time that daylight illuminates.

Overview all this research, we concern that the designers can truly use them to improve their indoor design, especially for small indoor space. It is plausible that this research can help cities to save energy and improve people's life quality. This paper aims to be helpful for people who have to live in a small space and make their lives in the city happier and more enjoyable.

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