Scientific Research Publishing

Open Journal of Social Sciences, 2024, 12, 486-500
https://www.scirp.org/journal/jss
ISSN Online: 2327-5960
ISSN Print: 2327-5952

Current Situation and Optimization Strategy of Roof Space in Chengdu Business District

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How to cite this paper: Fang, Y. Y., Chen, Z. L., & Zeng, M. Y. (2024). Current Situation and Optimization Strategy of Roof Space in Chengdu Business District. *Open Journal of Social Sciences, 12,* 486-500.
https://doi.org/10.4236/jss.2024.121033

Received: December 7, 2023
Accepted: January 28, 2024
Published: January 31, 2024

Abstract

With the development of Chengdu business district, the roof space of office buildings and their podium buildings has been greatly utilized. Through field investigation, the roof space of office buildings in Chengdu is divided into three types by taking photos and observing records, and the problems of functional zoning, plant configuration and functional facilities are summarized. And through the on-site questionnaire to the working group, understand the basic situation and behavior characteristics of the main users of the roof space in the urban business district. Based on the basic situation of field observation and the analysis of questionnaire results, the existing problems of roof space in Chengdu business district are analyzed: 1) excessive pursuit of commercial benefits; 2) lack of novelty in plant allocation; 3) the facilities are relatively simple. Corresponding to the problem, the paper puts forward some suggestions for optimizing the roof space of Chengdu business district.

Keywords

Urban Business District, Roof Space, Working Population, Optimization Strategy

1. Introduction

Green space can relieve people's pressure and bring health benefits to people, but with the acceleration of urbanization in China, the land use of urban business districts is becoming together, resulting in the compression of green space and less and less green space for working people. In this context, the roof space of the city's business district has become one of the few accessible green Spaces.

Chengdu, as the core city of Shuangcheng economic circle in Chengdu-Chongqing area, in order to provide more job opportunities and enhance the enthusiasm of working people, the development of the roof space of the business district has been well promoted. However, there are still big problems in the current stage of the roof space in Chengdu's business district, such as unclear functional positioning and chaotic facility configuration, which hinder the use of working people. In order to create a better roof space and provide a more comfortable rest environment for the working crowd, this paper summarizes the problems of 28 roof Spaces in Chengdu business district through field investigation and questionnaire survey, analyzes the characteristics and behavior patterns of users, and puts forward optimization suggestions for the roof space of Chengdu business district.

The study of roof garden abroad can be traced back to a long time ago. The hanging garden in ancient Babylon was recognized as the birthplace of roof greening (Li et al., 2001). In 1926, Le Corbusier once again proposed the concept of "roof garden" in "Five Points of New Architecture", and pointed out that roof garden is part of people's life scene (Corbusier, 2004). China's research on this aspect started relatively late, but since its rise, studies on roof space of buildings with different functional use types, such as commercial buildings (Lu, 2013) and public buildings (Lu, 2013), began to appear. Although the roof garden originated earlier, the research on the environmental benefits and optimization strategies of the roof garden has just begun to rise. Lin Jiaxin et al., through a controlled experiment, studied the impact of hanging gardens on the health of residents in residential areas and found that factors such as green vision rate would affect residents' feelings (Lin et al., 2023). Based on the evaluation of the beauty degree and ecological benefits of commercial rooftops in Chengdu, Du Jiazhu proposed optimization strategies for roof gardens (Du, 2023). Feng Maoheng et al. found that species diversity, structural stability, plant expansion and planting density of plant landscape are the decisive factors affecting the ecology of roof garden plant landscape, which is of great significance to the construction of sustainable roof garden plant landscape (Feng et al., 2023). Ma Lizong made a comprehensive evaluation of roof greening in the central urban area of Jinan City and proposed optimization strategies (Ma, 2023). Gao Yan promoted people's physical and mental recovery through healing landscape design, further enhanced the landscape value of commercial building roof gardens, and hoped to provide a new reference for the subsequent healing landscape design of commercial building roof gardens in China (Gao, 2023). Taking the roof garden of a primary school in Nanjing as the research area, Wang Rui introduced the concept of landscape performance evaluation based on user needs and the actual situation of the site, and proposed the research method of evaluation system construction and design strategy accordingly (Wang et al., 2022). In general, there are more studies on the roof space of commercial buildings and residential buildings, and there is still a large gap in the study of the roof space of business district.

2. Research Method and Research Content

This paper adopts the combination of observation method and questionnaire survey method. In the first part, 28 roof Spaces are classified by taking photos, recording and other methods, and the plan of 28 roof Spaces is drawn to analyze the functional zoning characteristics of the roof space of Chengdu business district, and the characteristics of plants and facilities are summarized. The type is divided by observing the combination of building groups. By taking photos and observing people, the functional partitions are divided by the types of facilities and the behavioral characteristics of users. Plant species were identified by taking photos, and their community and structure were classified. Facilities are categorized by usage observations.

The second part uses the questionnaire survey method. (Table 1) The location of the questionnaire is the roof space of the business district of Chengdu, and the people facing the surrounding office crowd are the main activity time is from 12 noon to 14 o'clock on working days and from 17 o'clock to 22 o'clock in the evening. These two periods are lunch breaks and working hours of the working population, and the utilization rate of the roof space is relatively high, which helps to obtain more user experience.

3. Survey and Analysis of Roof Space Results

3.1. Type Division

According to the architectural combination, the 28 roof Spaces can be divided into three types: the roof space used by office buildings and commercial complexes, the roof space used by office buildings and residential buildings, and the roof space of pure office buildings.

Table 1. Working population questionnaire.

Type of question	Question	Option or reference option			
Basic information	Sex, age	M/F, age			
Health status	Work stress	Very high	High	Medium	Low
	Physiologica	Excellent	Good	Medium	Poor
	Mental health	Excellent	Good	Medium	Poor
	Social health	Excellent	Good	Medium	Poor
Use of roof space	Frequency and length of use of roof	Times/week			
	Activities that people would like to do on the roof space during their leisure time on weekdays	Examples: exercise, sitting, talking, eating, drinking, watching, drinking tea, playing chess, playing cards, reading books, etc.			
	Environmental elements in the rooftop space that have the greatest impact on oneself	All environmental elements that can be seen in the scene. Examples: plants (green visibility, community type, vertical structure, horizontal structure), buildings (height, number), bodies of water (form, area), facilities (type, number), sky (sky openness), hard surfaces (visibility), etc.			

1) Roof space shared by office buildings and commercial complexes

The first type is the roof space used by office buildings and commercial complexes. Most of them are high-rise office buildings connected to the commercial complex, and the roof space is the top of the commercial complex, such as Chengdu Raffles Square. The staff of the shopping mall can go to the top roof space for recreation, while the working crowd of the office building can be reached directly from the inside of the high-rise building, such roof space is mainly used by the staff and office crowd in the shopping mall.

2) The roof space used by the office building and the residential building

The second type of roof space used by office buildings and residential buildings is mostly commercial complex at the bottom, and the surrounding high-rise buildings are residential buildings and office buildings, such as Chengdu Impression City. This type of roof space is connected to the residential buildings and, to ensure privacy, is generally not open to the commercial complex at the bottom, but can be reached from inside the office building and is mainly used by residents and office groups.

3) Roof space of office building

The third type is pure office building roof space, most of the multi-storey buildings are composed of high and low scattered, generally have a sense of design, and only for the office building inside the office crowd open to use, Zhongjian Binhu Design Co., Ltd. office building roof space is a very typical third type of roof space.

3.2. Function Division

The structure of the roof space of each business district is different. According to the preliminary research and past literature, the roof space type can be divided into six different areas according to their functions: open communication area, private rest area, sports and fitness area, and transportation functional area. The functions and features of each partition are as follows:

1) Open the exchange area

Working people in urban business districts need frequent communication and exchange. In addition to business-oriented communication in the office, colleagues also need more casual and relaxed communication, so as to enhance the feelings between colleagues and promote team cooperation. The open exchange area on the roof space of the city's business district was created for this kind of activity.

2) Private rest area

Psychological studies have shown that people want the area they live in to be controllable, so it is necessary to provide a certain privacy space in the roof space of the business district to achieve the territorial needs and self-control needs of the working crowd. The private rest area can meet the following psychological needs of the working crowd:

a) The need for solitude, fully feel the control of the space in the exclusive

small space.

b) Emotional catharsis, release the anxiety caused by work pressure without being disturbed.

3) Self-reflection and introspection, all-round cognition of self

4) Sports fitness area

The sports fitness area is a place for people under high pressure to carry out sports activities and exercise in the roof space of the urban business district. It is a kind of sports field built for special sports activities, such as basketball court and running track. One is a comprehensive place for simple exercise, generally set up table tennis tables, fitness facilities, etc.

5) Traffic functional area

The roof space transportation function area is different from the ground, which can connect two high-rise buildings for working people to pass through.

3.3. Plant Profile

With reference to the Vegetation of China, the vegetation types of the rooftop plant communities in Chengdu business District were firstly divided based on the characteristics of the plant communities themselves and the ecological relations between the communities. The main ecological appearance was taken as the higher taxonomic unit, and the combination of dominant species and marker species was taken as the middle and lower taxonomic unit. Based on the above classification principles, the 28 roof plant communities investigated were divided into five types: evergreen deciduous broadleaf mixed community, evergreen broadleaf community, deciduous broadleaf community, broadleaf mixed community and bamboo mixed community. The number of evergreen deciduous broad-leaved mixed plant communities was the largest, with 12, accounting for 42.86%. There were 10 evergreen broad-leaved communities, accounting for 35.71%. There was one deciduous broad-leaved community, accounting for 3.57%. There were 3 mixed communities in bambusa and 2 mixed communities in needlepoint, accounting for 10.71% and 7.14%, respectively. On the whole, the roofs of office buildings in Chengdu show a plant landscape style dominated by evergreen deciduous broad-leaved mixed community, followed by evergreen broad-leaved community, with complex plant community levels and rich seasonal changes.

All are mixed in horizontal structure. In the vertical structure, the number of Qiao-irrigation-grass stratified communities was the largest, with a total of 14 communities, accounting for 50%. There were 14 communities of "Qiao-irrigation", "Qiao-grass" and "irrigation-grass", accounting for 50.00%. To sum up, it can be concluded that the vertical structure of the roof plant community in Chengdu business district is divided into double layer mode and double layer mode, which jointly build a harmonious roof community landscape.

From the perspective of plant characteristics, there is little difference between different types of roof Spaces, but the plant characteristics of different zones are

quite different, mainly in the type and quantity. Most of the plants in the open rest area are ornamental plants with rich seasonal changes, but the number is not large and will not occupy the space of commercial facilities too much. Plants in the private rest area are generally plants that can separate the space from the sense of boundary, and most of them are evergreen plants, which is conducive to creating a small space with strong privacy and cool. The plants in the sports fitness area are generally tall evergreen trees, creating a wide and shaded space to promote people's exercise and fitness; the plants in the transportation functional area are more similar to those in the sports fitness area, generally tall evergreen trees, which can not block people's sight and allow people to pass quickly.

3.4. Facility Profile

In terms of facility types, different types of roof Spaces differ greatly.

The first type of roof space faces the office crowd and the people in the mall (including the mall staff and the people who come to the mall to eat and shop), and there are more commercial facilities such as restaurants and cafes, and they are rich in variety and have strong profitability. At the same time, some sports facilities such as basketball courts and yoga studios are mainly for profit. This kind of roof space has more people coming and going, and lacks private space.

The second type of roof space faces the crowd of office people and residents. This type of roof space contains more private Spaces, and the main facilities are seats and gazebos. Combined with a large number of plants, it creates a refreshing place for the users. There are also fitness equipment, table tennis table, children's slide and other small sports and entertainment facilities, which can provide exercise opportunities.

The third type of roof space facilities are relatively simple, generally arranged with plants combined with rest seats, and the most important functions are static leisure, such as reading books, newspapers, chatting, closing eyes and so on.

4. Analysis of the Results of the Survey Population

Through the on-site questionnaire survey of the surrounding working groups in the roof space of Chengdu city, 236 questionnaires were obtained, 27 invalid questionnaires were excluded, and 209 valid questionnaires were obtained. The survey results are as follows.

4.1. Investigate the Basic Situation of the Population

In this survey, there are 93 men, accounting for 44.5% of the total, and 116 women, accounting for 55.5% of the total. (**Figure 1**)

Through sorting and statistics on the age of the questionnaire group, the following results are obtained: 49 people aged 18 - 25, accounting for 23.44% of the total number. There were 70 people aged 26 - 35, accounting for 33.49% of the total number. There were 62 people aged 36 - 45, accounting for 29.67% of the total number. There were 28 people aged 46 - 60, accounting for 13.4% of the

total. (Figure 2)

4.2. Investigate the Stress and Health Status of the Population

The stress and health status of the survey group are as follows through the sorting of questionnaires.

In terms of work pressure, there are 26 survey office workers who feel very high pressure, accounting for 12.44% of the total; 104 people, accounting for 49.76% of the total, felt the greatest pressure. 68 people, accounting for 32.54% of the total, felt moderate pressure. Only 11 people felt less pressure, accounting for 5.26% of the total number. On the whole, the stress value of the surveyed working group is generally high. (Figure 3)

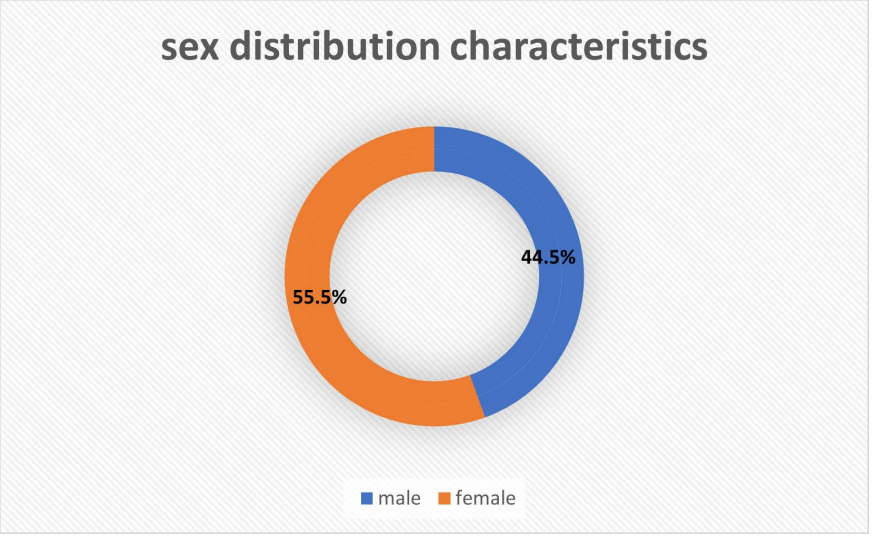

Figure 1.Sex distribution characteristics.

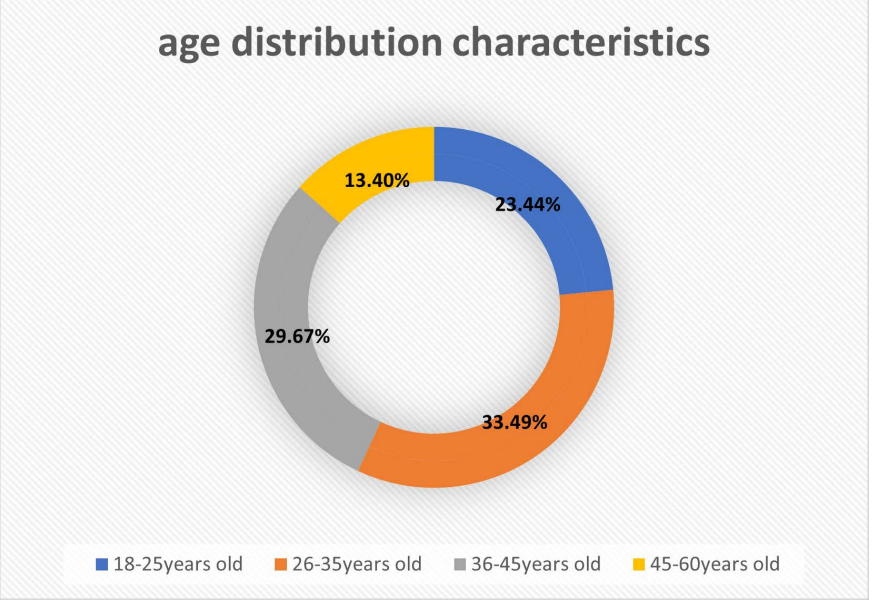

Figure 2. Age distribution characteristics.

In terms of physical health, there were 78 survey workers who felt that their physical condition was excellent, accounting for 37.32% of the total; 103 people, 48.28% of the total, felt that they were in good health. There were 26 people who felt that their physical condition was medium, accounting for 12.44%; there were 2 people, accounting for 0.96% of the total, who felt that their health condition was poor. On the whole, the evaluation of self-physical health of the survey group is above average, but the number of self-evaluation is significantly more good than excellent, indicating that many people with high work pressure have more minor health problems and fewer major diseases. (Figure 4)

In terms of mental health, there were only 35 survey workers who felt that their mental health status was excellent, accounting for 16.75% of the total; 98 people, accounting for 46.89% of the total number, thought their health condition

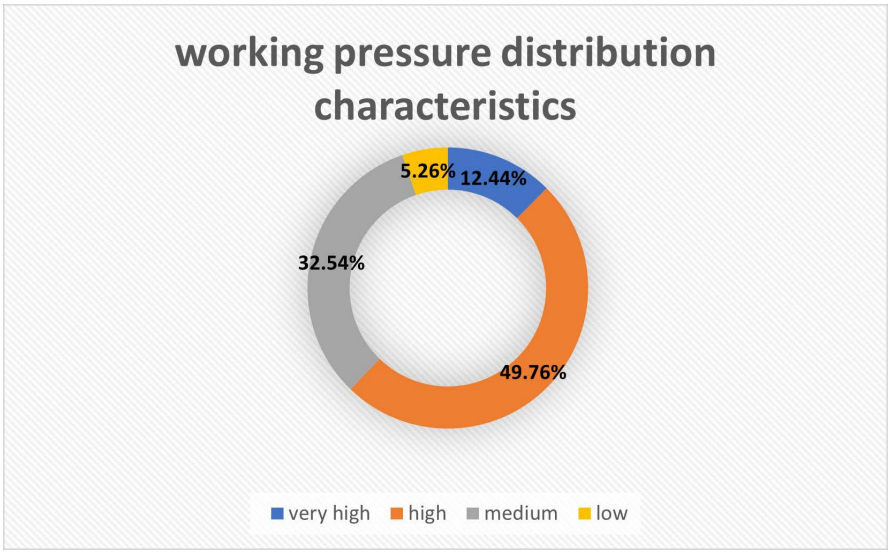

Figure 3. Working pressure distribution characteristics.

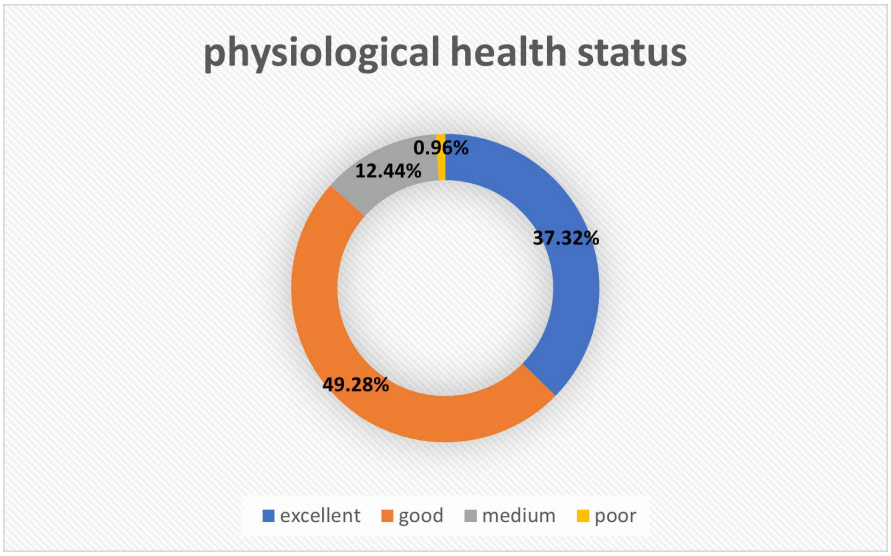

Figure 4. Physiological health status.

was good. There were 62 (29.67%) people who felt that their physical condition was moderate. There were 14 people, accounting for 6.7% of the total, who felt that their health condition was poor. On the whole, the mental health self-evaluation of office workers is more good and poor, and less people are evaluated as excellent, indicating that many high-pressure people are suffering from psychological and emotional troubles. (Figure 5)

In terms of social health, 162 survey office workers, accounting for 77.51% of the total, felt that their social health status was excellent. 31 people, 14.83% of the total, felt that their social health condition was good. 13 people, 6.22% of the total, felt that their social health status was medium. There were 3 people, accounting for 1.44% of the total, who felt that their social health status was poor. On the whole, the social health self-evaluation of the people with high work pressure was higher. (Figure 6)

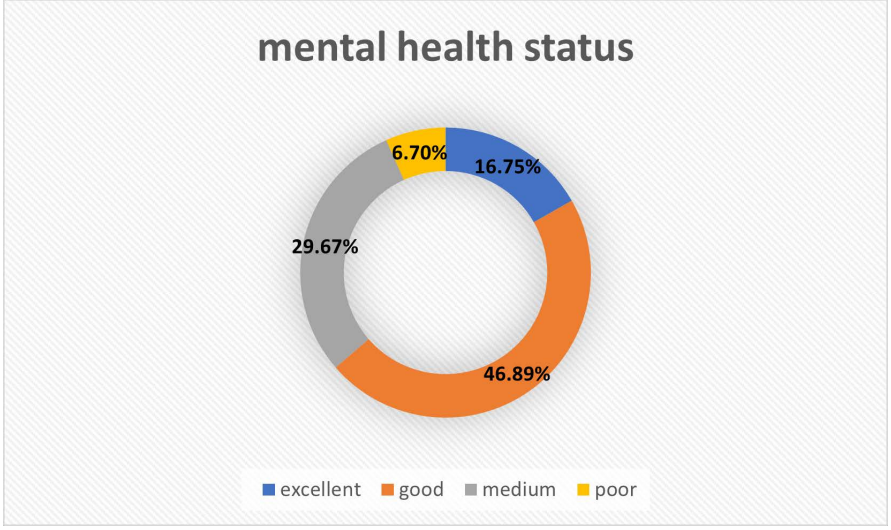

Figure 5. Mental health status.

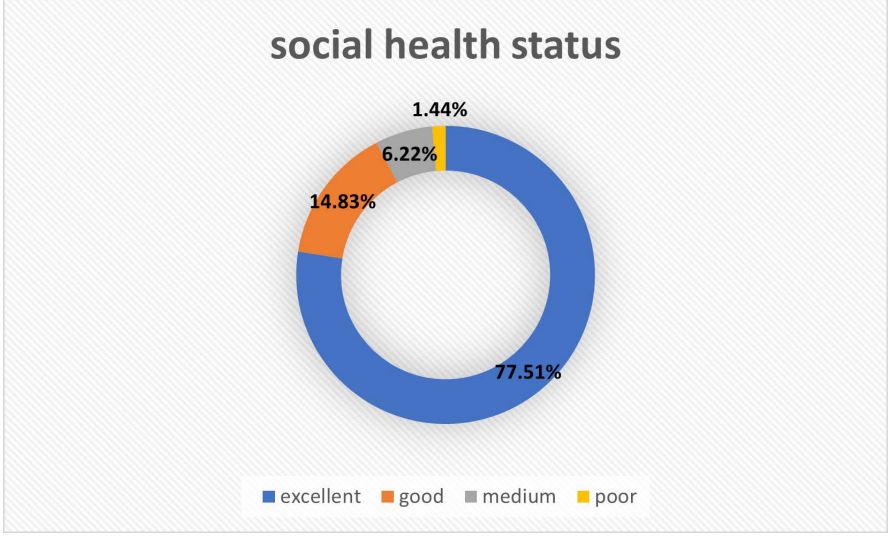

Figure 6. Social health status.

Three kinds of health status of people with high work pressure were analyzed comprehensively. Mental health status was the most serious problem, and the proportion of self-rated mental health was the highest. Secondly, in terms of physical health, more people choose good and middle school; Compared with the first two, the social health problems were the least, and the people who rated themselves as excellent were the most.

Overall, the stress value of the working population is large, and the physical and mental health status is poor, which needs to be improved urgently. At the level of urban planning, it is a good method to improve the quality of the living environment, increase the number of green Spaces near the company, enhance the quality of the roof space of the business district, and provide an environment for working people to relax, exercise and socialize, so as to relieve the pressure of working people and improve their health.

4.3. Use Agent Behavior Characteristics

To explore the characteristics of the roof space of the urban business district, it is necessary to first understand the behavior pattern of high-pressure people in the urban business district and the use of the roof space of the urban business district, and fully understand the needs of users, so as to create an environmental space to meet the needs and maximize the value of the roof space. Through the analysis of the behavior and activities of the users of roof space in urban business districts, the following points can be summarized:

1) Regularity

The use of roof space by high-pressure people is relatively regular, which is mainly reflected in commuting between rest and work. The roof space of the skirt house makes it convenient to pass between the office high-rise buildings and provides convenience for the high-pressure people. During work breaks or lunch breaks, the roof space can provide a rest place for people under high pressure at work.

2) High efficiency

In urban business districts, the urban green space is often some distance away from the office. For people with high working pressure whose rest time is precious, the roof space located on the top of the building or the podium building has high accessibility, which can effectively save the rest time.

3) Diversity

With the development of society and the progress of technology, many types of work are no longer dependent on fixed production equipment or resources, and the working population has stronger flexibility and diversity needs for the environment. In the rest time at work, people with high work pressure will also have some leisure activities, such as walking, chatting, basking in the sun, drinking coffee, sports and so on. As a new type of place in the city, the roof space needs to create an interesting and attractive high-quality environment to attract people to go out and improve their psychological state.

4) Communication

Most activities in urban business districts require multi-party participation and teamwork. In addition to business discussions conducted by teams together, there are also spontaneous private interactions between individuals, such as technical work discussions and after-work gatherings, which are positive behaviors that can promote social interactions and are affected by the environmental atmosphere. The openness or semi-privacy of some roof Spaces will promote different types of communication activities.

4.4. Investigate the Use Characteristics of Roof Space by People

According to the survey on the use of the surrounding roof space by the high-pressure workers, there are 26 survey office workers who have never used the roof space, accounting for 12.44% of the total. 84 people used the roof space once or twice a week, accounting for 40.19% of the total number. There are 76 people who use the roof space 3 - 5 times a week, accounting for 36.36% of the total. There are 23 people who use the roof space more than 5 times a week, accounting for 11% of the total. On the whole, among the people with high work pressure surveyed, most people will use the roof space around the work environment, and the people who use the roof space once to five times a week are the most frequent, and the people who never use it and use it more than five times a week are less. (Figure 7) According to the observation and interview results, as the most accessible green space in the city, workers tend to take activities in the roof space during work breaks (such as lunch breaks). After work, most office workers choose to go home directly instead of staying nearby. However, people have a wider use time range for green Spaces such as urban parks, which results in less frequent use of roof space than urban parks.

According to the activities that high-pressure people in the survey tend to carry out in the nearby rooftop space, the exercise methods such as playing

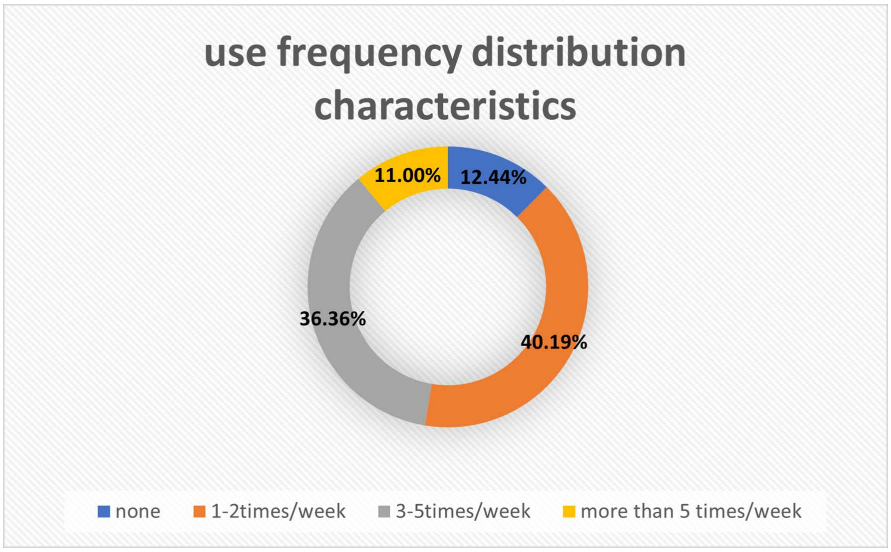

Figure 7. Use frequency distribution characteristics.

badminton and basketball filled in by the survey group are classified as sports, activities such as drinking tea and eating takeout are classified as eating and drinking, activities such as appreciating flowers and watching are classified as viewing, and activities such as reading books and newspapers are classified as reading. Classify activities such as chatting and making phone calls as conversations. The less mentioned activities, such as dog walking, are summarized into other activities, and the frequency of each activity is finally obtained (see Figure 8). Among them, walking and talking are more, followed by sports, eating and drinking, viewing and reading, and chess and cards are less mentioned. According to the observation and interview results, compared with urban green space, roof space is smaller, facilities are relatively simple, people can carry out limited activities, it is difficult to carry out large-scale activities. At the same time, the artificial nature of the roof space is strong, and some activities with strong natural characteristics cannot be carried out, such as fishing, picking and other activities will be limited

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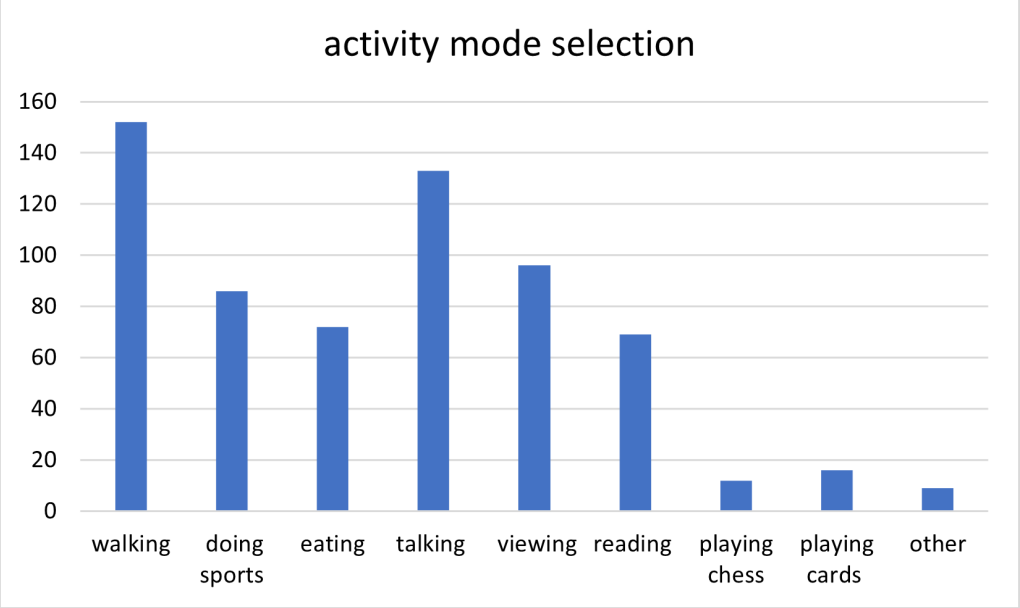

Figure 8. Activity mode selection.

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5. Existing Problems and Optimization Suggestions

5.1. Too Much Pursuit of Commercial Efficiency

This kind of problem is mainly for the first type of roof space, the use of this type of roof space is for the two groups of people, but because all of its ownership belongs to the shopping mall, most of the profitability is the main consideration, economic benefits are the main issue, the needs of working people are secondary. The consumption of food and beverage and the price of sports venues are high for ordinary office workers, so the utilization rate of such rooftop space facilities is low for working people. At the same time, this kind of functional composite roof space has a large crossover between the two groups of people, which lacks privacy for the working crowd.

For this type of roof, it can be partitioned and divided into part of the roof space dedicated to the office population to avoid the intersection of the two groups of people leading to poor use experience. At the same time, food and beverage can increase the coverage of the price, while meeting the daily needs of people who come to the shopping mall and office workers.

5.2. Plant Configuration Lacks Novelty

Through the statistics of various types of roof plants, it is found that the current arrangement of plants in the roof greening of office buildings in Chengdu is too

traditional, and the application of vertical structure and community types of plants is much the same as the greening arrangement of ground landscape, and the homogeneity phenomenon is very serious. The main reason for this problem is that the domestic research on roof greening plants is not rich enough to provide effective suggestions. On the other hand, it is because the planting of some characteristic roof greening requires specific requirements of special soil quality and load, and high cost hinders its development.

In order to reduce the spatial sense of a single plane of the roof space and form a difference from the ground landscape, the best viewing point in the site space can be determined. The combination of trees, shrubs and flowers and ground cover herbs, combined with vines, can create a hierarchical sense of plant landscape through planting in front and back positions, and use plants of different volumes and shapes and landscape facilities of corresponding heights to echo. This can create a better landscape effect than a single plant (Ye, 2022).

5.3. Relatively Simple Facilities

This kind of problem is more common in the third type of pure office building roof space. This type of roof facilities are mainly leisure facilities such as seats, and only a small number of roof facilities contain coffee shops, basketball courts and other facilities. A single leisure facility only meets the needs of working people to relax and rest, and does not take into account their more needs, such as entertainment and exercise.

In the roof space of such problems, fitness facilities and recreational facilities can be appropriately configured, such as table tennis tables, swings, etc., to promote people's physical exercise and enhance their health.

If the company's site conditions permit, design all kinds of roof Spaces with both functions, enhance the use of fun, improve the utilization rate, and increase the frequency of use of workers.

6. Summary

Through the field investigation of 28 roof Spaces in Chengdu business district, this paper understands the types, functional zones, plants and facilities of the roof space in the business district, which is conducive to optimizing the subsequent landscape design of the roof space in the business district. At the same time, a questionnaire survey was conducted on the main users of the roof space in the business district, namely the working group, to understand the stress and health status of the group, analyze the behavioral characteristics and the characteristics of the use of the roof space, which is conducive to putting forward suggestions from the perspective of the users and creating a human-centered healing roof space landscape.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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