Journal of Landscape Research 2023, 15(4): 31-34, 40

Influence of Urban Street Greening Design under the Concept of Green Healthy Cities: A Case Study of Hefei City

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Abstract In order to explore the influence of urban street greening, the street landscape of Changjiang West Road and Xiyou Road in Hefei City was selected as the research sample to study the design of urban street landscape under the concept of green healthy cities. The results show that the urban street landscape of Hefei City is single in design and plant type, and plant maintenance management is not good. It is proposed to strengthen the maintenance and management of street greening, increase the types of native plants, and improve cultural connotation, so as to enhance the artistry, regionalism and functionality of urban street landscape in Hefei City.

Keywords Green healthy cities, Urban landscape design, Street landscape design
DOI 10.16785/j.issn 1943-989x.2023.4.006

Urban streets are the skeleton of a city, and road greening is the network basis of urban green space[1]. Roads are one of the elements of urban development. To eliminate the fatigue of most office workers through excellent street greening design is the important significance of street greening design under the concept of green healthy cities.

In the process of urbanization, cities are faced with environmental quality problems such as air pollution, water pollution and heat island effect, as well as ecological problems such as ecosystem fragmentation and species reduction. Street greening is regarded as an important way to improve urban environment and ecological quality. Urban residents' pace of life and pressure are increasing, and but they lack the opportunity to contact the natural and green environment. Studies have shown that street greening can provide people with places for leisure activities, reduce life stress, and improve mental and physical health[2]. City image, city brand and tourism attraction are crucial to urban development. Street greening can beautify the urban landscape, enhance the image and attractiveness of a city, and promote the development of tourism. As the threat of global climate change becomes increasingly apparent, cities seek strategies to address climate change. Street greening can reduce urban heat island effect, increase carbon absorption, enhance urban adaptability, and promote urban sustainable development. According to recent data, the greening status of urban streets in Hefei City is relatively good. A certain degree of greening work has been carried out in urban street squares, parks, communities and other areas. There are many green belts, flower beds, lawns, trees and other landscapes in the city, providing a beautiful and comfortable environment for citizens.

Hefei Municipal government has been committed to the construction of urban greening and ecological environment protection, and has implemented a series of green policies and projects, including afforestation, construction of urban parks, greening transformation, etc. Consequently, these efforts have greatly improved Hefei's urban street greening, and have played a positive role in beautifying the city, improving air quality and enhancing residents' quality of life. Greening is still an ongoing process, and some areas or streets need to further improve and increase greening coverage.

1 Research objectives and significance

1.1 Research objectives

The research of urban street greening landscape is to explore how to improve the greening quality and landscape benefits of urban streets through reasonable planning, design and management, so as to improve the urban environment, increase the comfort level of urban residents, and promote urban sustainable development[3]. The purposes of studying urban street greening in Hefei are as follows:

(1) Enhancing urban environmental quality: Hefei is a rapidly developing city. Greening can improve urban air quality, water quality and soil quality, reduce urban heat island effect, provide fresh air and comfortable climate conditions, and create a livable environment for residents.

(2) Improving the ecosystem: the urban street greening of Hefei can not only increase the biodiversity of the city, but also provide habitats and food sources to support the balance and stability of the city's ecosystem.

(3) Increasing residents' space for leisure activities: street greening can create space for leisure activities, provide places for sports and social communication, and promote residents' healthy lifestyle.

(4) Enhancing the aesthetic and cultural value of the city: greening can not only increase the aesthetic and landscape value of the city, make the city more pleasant and attractive, form a unique urban image, but also retain and inherit the local cultural characteristics.

(5) Achieving sustainable development goals: the urban street greening of Hefei, which is a part of sustainable urban development, can promote the effective use of resources, energy conservation and environmental protection, and contribute to the realization of sustainable development goals.

1.2 Research significance

Improving urban environmental quality: urban street greening can increase the proportion of green space, improve air quality, inhibit CO_2 emission, reduce noise pollution and improve urban environmental quality[4]. Enhancing the urban landscape benefit: urban street greening can increase the city's beauty and visual effect, improve the urban landscape benefit, and strive for more tourism resources and cultural influence for the city. Increasing residents' comfort: urban street greening can increase green space area and tree coverage, alleviate urban heat island effect, and improve residents' comfort and quality of life[5]. Promoting urban sustainable development:

Received: July 13, 2023 Accepted: August 9, 2023
Sponsored by the Innovation Training Planning Project for College Students in Anhui Province (S202112216137); Scientific Research Team Project of Anhui Xinhua University (kytd202202).

urban street greening, as one of the important means to promote urban sustainable development, can improve the efficiency of land use, improve water resources management, promote urban economic development, and increase the value of environmental assets[6]. Specifically, the significance of studying the urban street greening of Hefei is multifaceted, and several important aspects are shown as follows:

(1) Improving urban environmental quality: Hefei is a rapidly developing city. Urban street greening can improve urban environmental quality, reduce urban heat island effect, provide fresh air and comfortable climate conditions, and create a healthy and livable living environment for residents.

(2) Ecosystem balance: urban street greening can not only increase the green space of the city, but also provide habitats and food sources to support the balance and stability of the urban ecosystem. Greening also helps to protect traditional biodiversity and ecological chains, and provides a good urban ecological environment.

(3) Improving the quality of life of residents: street greening can provide space for leisure activities and create a healthy lifestyle. The green environment enables residents to be close to nature, enjoy outdoor activities and promote physical and mental health. At the same time, the beautiful green landscape can also improve the happiness and quality of life of residents.

(4) City image building: through the study of urban street greening in Hefei, reasonable planning and management strategies can be formulated to create a beautiful city image. A good green environment helps to enhance the beauty and attractiveness of the city, attract more tourists and investors, and contribute to the sustainable development of the city.

(5) Sustainable development: street greening, as a part of sustainable urban development, contributes to the efficient use of resources, energy conservation and environmental protection. Greening projects can reduce the temperature, purify the air, prevent land erosion, etc., which is conducive to the construction of a green and low-carbon city.

1.3 Research status at home and abroad

1.3.1 Foreign research status. From the 1960s to the 1970s, urban greening was popularized. In the 1980s, the theory and practice of urban greening were thoroughly studied. From the 1990s to the early 21st century, urban ecosystem and greening planning were studied. In the 21st century, the combination of urban landscape ecology and urban planning, climate change mitigation and adaptation and carbon emission reduction were studied.

1.3.2 Domestic research status. In the 1980s, the concept, objectives and planning principles of urban greening were studied. In the 1990s, the domestic research on urban greening theory entered the peak period, and the research content mainly focused on greening types, greening planning, greening management, greening design and so on. From the beginning to the middle of the 21st century, the research on urban green space ecological services, urban forest ecosystem and urban landscape ecology gradually became a research hotspot. In recent years, the research on urban complex greening system, green transportation and carbon sink ecosystem has been paid attention to.

2 Urban street design under the concept of green healthy cities

2.1 Concept of green healthy cities

A green city is a green ecological city, and a healthy city is a city that is physically and mentally healthy for citizens, while "a green healthy city" is a composite term of a green city and healthy city, having characteristics of both green and health. A green city is the foundation of a healthy city, and a healthy city is the purpose of a green city[7]. The concept of green healthy cities emphasizes green and health as the core, and pursues the sustainable development of the city and the health and happiness of residents. Hefei can realize the goals of green healthy cities through street greening.

A green healthy city needs to meet the following goals: ① environmental health. Hefei's street greening can improve the urban environment, provide fresh air, reduce noise and exhaust pollution, create a good living environment for citizens, and promote physical and mental health. ② Natural connection. Street greening creates a naturally connected space for Hefei, enabling citizens to contact and enjoy nature. The setting of green belts, parks and leisure space promotes interaction between people and nature, and provides places for leisure, recreation and exercise. ③ Social interaction. Hefei's street greening can encourage social interaction and community participation. Parks, green spaces and other green landscapes are places for citizens to gather, communicate and interact, promoting community cohesion and interaction among residents. ④ Ecological balance. Street greening helps to protect and restore ecosystem, provide habitats and food sources, maintain biodiversity and protect the ecological balance of the city. This is in line with the importance and protection of ecosystem in the concept of green healthy cities. ⑤ Sustainable development. Street greening is a part of sustainable urban development in Hefei. Greening can reduce urban heat island effect, save energy, create ecological corridors and provide ecological services, so as to build Hefei into a green, low-carbon and sustainable city.

The goal of the green healthy city concept is to improve the quality of life and happiness of residents, protect the natural environment, and achieve sustainable development. This concept is increasingly being used and promoted in urban planning and design to build healthier and more livable cities.

2.2 Urban street greening

Street planting means planting trees and hedges, arranging flower beds, tree-lined walks, street gardens and greening in front of buildings on both sides of streets and in dividing zones[8].

2.3 Design of urban street greening landscape

2.3.1 Principles of street landscape design. The principles of street landscape design need to be combined with the actual situation and specific needs, usually including the following aspects:

(1) Adaptability: the design must adapt to the local natural and human environment, and meet the needs of different uses and functions according to the characteristics of blocks, buildings and the surrounding environment.

(2) Safety: the design must ensure the safety of pedestrians, vehicles, and other users, including vehicles, pedestrian flow, islands, sidewalk crossings, parking areas, lights, signals, lines, and road markings.

(3) Publicity: the design of public space should be open, so that everyone can freely use and enjoy it. The design should meet the needs of different groups of people as much as possible, including the elderly, the disabled, children, etc.

(4) Sustainable development: the design should consider environmental protection, resource conservation, energy utilization and other factors, such as using environmentally friendly materials, reducing energy consumption, and improving water utilization rate.

(5) Aesthetics: Landscape design should take aesthetics as the starting point, improve the beauty and artistry of street landscape through various means such as color, form, proportion, plant types and materials, and promote the development of urban culture[9].

(6) Functionality: Landscape design should take full account of functional needs, not only conform to practicality, but also stimulate creativity and imagination, so that people can

freely move and communicate in a block, and meet different needs[10].

2.3.2 Significance of street greening landscape in urban construction. Street greening landscape is closely related to urban construction, and has the following significance:

(1) Beautifying the image of a city: street greening landscape can increase the landscape value and beauty of the city, make the city more livable and pleasant to travel, and improve the image and brand value of the city.

(2) Improving urban quality: street greening landscape can improve air quality, increase oxygen content, reduce noise and heat island effect, improve urban air quality, and make the city more fresh and comfortable.

(3) Promoting social progress: street greening landscape helps to enhance citizens' awareness of environmental protection and ecology, improve social productivity and scientific and technological level, and promote sustainable urban development[11].

(4) Creating green space: street greening landscape can provide people with places for leisure, walking and sports, improve urban living space environment, and enhance urban public service function.

(5) Improving the ecological environment: street greening landscape helps to enhance urban biodiversity, protect the ecosystem, maintain natural ecological balance, and reduce soil erosion and other natural disasters[12].

(6) Promoting economic development: street greening landscape can increase public service facilities such as green space, parks and recreation facilities, improve real estate value, and drive the development of tourism and related supporting services[13].

2.3.3 Development trend of road greening design. With a deeper understanding of the role of road greening, road greening in Hefei has paid attention to its appreciation, culture and the improvement of the city's image instead of focusing on its single ecological protection, and its design form has gradually changed from regular to natural form; green layers and forest canopy lines have become more abundant, enhancing the ornamental and natural wild interest of green belts[14]. As the greening form of Hefei City changes from regular to natural form, regular hedgerows and shrub balls (such as *Photinia* × *fraseri*, and *Pittosporum tobira* (Thunb.) W. T. Aiton) that used to be pruned frequently are gradually reduced, and replaced by small shrubs (such as *Hypericum monogynum* L., *Kerria japonica* (L.) DC., *Jasminum mesnyi* Hance, and *Spiraea japonica* L. f.) and perennial flowers (such as *Ophiopogon japonicus* (L. f.) Ker Gawl., *Zephyranthes candida* (Lindl.) Herb., *Hemerocallis fulva* (L.) L., and *Iris tectorum* Maxim.) that do not need pruning. They have gradually become the main force of underground varieties for road greening, thus saving the labor cost of maintenance and reflecting the economy and sustainable development of road greening[15]. The characteristics of road greening are more prominent. According to different road conditions and geographical environment, by integrating the characteristic landscape or cultural connotation, the original monotonous and identical road greening has been transformed into a road greening landscape with various styles and outstanding characteristics. Road greening pays more attention to the greening of key areas, such as green belt islands, intersection green belts, diversion islands and other focal points. In recent years, Hefei has made a large number of use of flower border design in the transformation of road islands and intersection green belts. According to the changes of seasons, different flower and leaf plants are replaced, and featured pieces are combined to highlight various theme designs, thus adding culture and interest to road greening.

Hefei City attaches more and more importance to the design of slow traffic system, and builds the sidewalk into a characteristic green way combined with green belts outside the red line. Walking trails, jogging tracks, leisure venues, fitness venues, etc. are added inside the green belts outside the red line, and leisure, viewing, fitness and other functions are integrated into the design of roadside green belts, thereby creating a human road landscape that can meet the needs of various people and has high ornamental value through different site design and green groups. With the implementation of "green healthy cities", more new design ideas and methods have been integrated into road greening design. Hefei has added ecological rainwater management measures on a number of new roads, and added sinking green space, biological retention ponds and constructed wetland to dividing belts and roadside green belts, so as to create a low-impact development road landscape[16].

3 Arrangement of plants along urban streets

3.1 Arrangement methods of plants

Basic arrangement methods of urban street landscape plants in Hefei City are as follows:

(1) Planting trees: trees are needed along Xiyou Road in Hefei to prevent sun exposure, block rain and beautify landscape. The arrangement of tall and short trees should be reasonable, and the types of trees need to be diversified. Trees, shrubs and grasses suitable for the local climate and land natural environment should be selected.

(2) Covering ground plants: right plants should be planted along Xiyou Road in Hefei to well fix the soil, reduce soil erosion, inhibit odor, and reduce noise. Covering ground plants can also provide an intermediate landscape effect for the home through herbal plants.

(3) Three-dimensional greening: along Xiyou Road and Changjiang West Road in Hefei, vertical greening or hanging flower baskets are adopted in the street building facades, street light poles and other spaces for landscape decoration, so as to enrich street landscape and make the street more dynamic.

(4) Reasonable planting: according to the actual conditions of Xiyou Road and Changjiang West Road in Hefei City, landscape plants are rationally allocated to sidewalks, driveways, central green belts, parks and squares, and factors such as plant height, color, seasonality, light, drainage and variety are taken into account to make the best landscape effect of plants. The plant design of different areas also needs to meet the requirements of planning function of indoor container plants and the opportunity to increase the utilization value of space in this period.

3.2 Plant species and arrangement forms

According to Table 1 and 2, Xiyou Road and Changjiang West Road in Hefei City have relatively single plant species, fixed plant arrangement forms, and less green land on urban roads, and lacks street green space. Besides, the selection of tree species is not reasonable, and there is a lack of color matching. The design of greenbelts beside the streets is not humanized and lacks activity space, so the principle of scientific planning should be strengthened. The design model is less, and the ecological and social effects of greening cannot be realized.

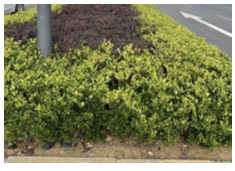
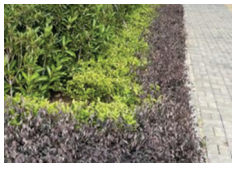
4 Conclusions

The urban street landscape of Hefei City was studied from every dimension. Street landscape not only has the landscape function of spatial structure, but also has the function of alleviating eye fatigue. Urban street greening occupies an irreplaceable position in urban construction and landscaping. Its landscape forms are diverse and kinds are rich. Besides ornamental value, there are many other rich connotations. Of course, the flower borders of different plant communities also have their

Table 1 Arrangement forms of plants

Arrangement form	Landscaping form	Selection condition	Common tree species
Isolated planting	Isolated planting means planting an arboreal ornamental fruit tree alone in a certain closed space to fully reflect the beauty of the individual form of the tree	The tree has a strange posture, or the flowers are of high cultural ornamental value. It is tall and plump, and has bright colors, luxuriant flowers, a long life, a certain fragrance or seasonal changes	*Pyrus*, *Malus spectabilis*, *Musa basjoo* Siebold & Zucc. ex Iinuma, *Ginkgo biloba* L., and *Cerasus pseudocerasus*
Group planting	Group planting is a combination of a few to seven or eight ornamental fruit trees of the same or different species	It can show the group beauty of plants, and the individual beauty of tree species can be also felt. It is generally required that contrast can be formed in all aspects	*Punica granatum* L., *Prunus persica* (L.) Batsch, *Prunus armeniaca* L., and mulberry
Mass planting	Mass planting refers to the group combination of the same tree species, and trees has a large number to show the beauty of the group	Scale change and a sense of hierarchy should be more diverse, such as increasing the number of ornamental trees and the species of trees	*Eriobotrya japonica* (Thunb.) Lindl., *Ficus carica* Linn., and *Myrica rubra* Lour.
Rank planting	Rank planting refers to ornamental fruit trees in a row or rows of ranks, and trees are planted at a certain distance	It can provide a beautiful canopy line to the landscape, outline the landscape or display orientation	*Cocos nucifera*, *Mangifera indica* and *Ziziphus jujuba*
Coupled planting	Coupled planting means planting one or more ornamental trees at the entrance or in front of a building to make them symmetrical and echo each other	The varieties and volumes of ornamental fruit trees should be roughly equivalent, without absolute symmetry, and a certain balance can be maintained	*Citrus reticulata* Blanco, *Ginkgo biloba* L., and *Diospyros kaki* Thunb.

Table 2 Distribution status of urban street greening in Hefei City

Research status	Plant group	Planting mode	Research status	Plant group	Planting mode
	Street intersections are planted with *Pittosporum tobira* (Thunb.) W. T. Aiton	Planting in patches		*Berberis thunbergii* 'Atropurpurea' and *Ligustrum* × *vicaryi* Rehder	Planting in patches
	*Rosa chinensis* Jacq. and *Ophiopogon bodinieri* H. Lév.	Planting in patches		*Euphorbia prostrate* Ait., *Yucca gloriosa*, *Serissa japonica* (Thunb.) Thunb., *Acer palmatum* Thunb. in Murray, *P. tobira* (Thunb.) W. T. Aiton, etc.	Planting in patches
	*R. chinensis* Jacq.	Planting in patches		*Cinnamomum camphora* (L.) Presl., *P. tobira* (Thunb.) W. T. Aiton, *Ligu-strum phnom* penh, etc.	Isolated planting and planting in patches
	*Photinia* × *fraseri*, *Ligustrum lucidum* Ait., *Loropetalum chinense* var. *rubrum* Yieh, and *Cinnamomum camphora* (L.) Presl.	Planting in patches and rank planting		*P. tobira* (Thunb.) W. T. Aiton	Planting in patches
	*Hosta plantaginea* (Lam.) Aschers., *Viola tricolor* L., *Hydrangea macrophylla* (Thunb.) Ser., *L. chinense* var. *rubrum* Yieh, *Rosmarinus officinalis* L., O. bodinieri H. Lév., etc.	Planting in patches		*R. chinensis* Jacq., *V. tricolor* L., *Jacobaea maritima*, *L. lucidum* Ait., *Spiraea cantoniensis* Lour., and *Coreopsis basalis* (A. Dietr.) S. F. Blake	Planting in patches
	*Abelia* × *grandiflora* (André) Rehd., *Trachelospermum jasminoides* 'Flame', *Jacobaea maritima*, *V. tricolor* L., *Nan-dina domestica* Thunb., *Teucrium fruticans* L., etc.	Planting in patches		*V. tricolor* L., *Lagerstroemia indica* L., *Osmanthus* sp., *Glandularia* × *hybrida* (Groenland & Rümpler) G.L.Nesom & Pruski, etc.	Planting in patches and isolated planting

own unique color combinations. However, it is necessary to strengthen plant protection and improve plant species in the urban street greening of Hefei City. Therefore, it is of great significance to explore the influence of urban street greening landscape.

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(To be continued in P40)

Table 1 Connection and control values of space syntax

Functional area	Connection value	Control value
North gate	3	0.73
Express delivery service area	3	0.68
Gusong Garden	5	1.29
School hospital	3	0.54
Family living area 2	5	1.34
Integrated teaching area	7	1.71
Student dormitory area 2	7	1.48
Yuxiu Garden	5	0.90
Integrated service area	5	0.85
Family living area 1	5	1.02
Logistics service area	3	0.54
Administration building	4	0.76
South gate	4	0.76
Student dormitory area 1	6	1.24
Sports ground	3	0.98
East gate	2	0.67
Boyuan teaching building	3	1.17
Library information building	3	0.87
Hanxue teaching building	5	1.23
Small playground	3	0.68
Guojiao living area	7	2.43
Zhixiu Garden	1	0.14

Table 2 Connection, depth and distance values of different functional areas based on space syntax

Functional area	Connection value	Depth value	Distance value (to south gate)//km
North gate	3	2.86	0.46
Express delivery service area	3	2.62	0.44
Gusong Garden	5	2.33	0.40
School hospital	3	2.71	0.45
Family living area 2	5	2.38	0.48
Integrated teaching area	7	1.95	0.30
Student dormitory area 2	7	2.00	0.31
Yuxiu Garden	5	2.10	0.32
Integrated service area	5	2.14	0.35
Family living area 1	5	2.19	0.38
Logistics service area	3	2.48	0.40
Administration building	4	2.29	0.05
South gate	4	2.24	0.00
Student dormitory area 1	6	2.14	0.20
Sports ground	3	2.57	0.32
East gate	2	3.33	0.18
Boyuan teaching building	3	2.57	0.30
Library information building	3	2.86	0.35
Hanxue teaching building	5	2.24	0.24
Small playground	3	2.57	0.39
Guojiao living area	7	2.19	0.33
Zhixiu Garden	1	3.14	0.55

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