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New Residential Models in Guanzhong Region under the Background of Green Buildings

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Abstract: In the context of green buildings, the research on new residential models in the Guanzhong area has attracted much attention. As a historical and cultural city with a long history of city building, the Guanzhong region's Xiguan Ancient City in Qinzhou District is one of the most representative residential areas. However, with the continuous improvement of modern living needs, local ancient dwellings can no longer meet people's needs, and their current situation is not coordinated with the modern style of the city. Transformation and renewal are imperative. Traditional residential buildings are developed and formed under specific natural climates and environments, which not only have extremely high historical and cultural value, but also contain rich green wisdom. On the basis of examining modern green building and sustainable development theory, while looking at traditional residential buildings, we can discover the green experience and shortcomings contained therein. By combining modern architectural design techniques for revision, the inheritance and development of residential buildings can be achieved, while promoting research on localization of green buildings. Therefore, in the study of new residential models in the Guanzhong region, the green wisdom of traditional residential buildings can be combined with modern green building concepts to explore green building solutions that are in line with the local climate, environment, and cultural characteristics. This is of great significance for improving the quality of life of residents and promoting sustainable urban development. The results of the questionnaire survey indicate that the natural lighting optimization and adjustable shading scores of residential buildings in the Guanzhong area are relatively high, with scores of 13.2 and 11.1, respectively, indicating that they have done a good job in lighting and shading.

1. Introduction

With the intensification of global climate change and the increasing pressure on resources and environment, green buildings have become one of the important means to promote sustainable development. Green buildings aim to reduce energy consumption, reduce the consumption of natural resources, improve building quality and living environment. Through scientific and technological means and innovative design concepts, they achieve harmonious coexistence between buildings and the environment. In this context, the research and exploration of new residential models have become one of the important topics in today's society.

This article mainly focuses on traditional residential buildings in the Guanzhong region, as well as how to combine green building concepts for renovation and development. Firstly, the two main types of residential buildings in the Guanzhong region were introduced, along with their development history. The development stages from the 1980s to the early 21st century were sorted out. Next, the article provides a detailed analysis of the external characteristics of traditional residential buildings in Guanzhong, including spatial composition factors and spatial integration relationships, as well as considerations at the village planning level. Then, a qualitative analysis was conducted on the green experience of traditional residential buildings in Guanzhong, exploring aspects such as village planning and landscape patterns. Next, through experimental preparation and presentation of experimental results, the impact of various environmental factors in the urban green space system on the urban green space system was demonstrated, as well as the questionnaire survey results of objects familiar with green buildings.

2. Related Works

Experts have long conducted specialized research on new residential models and housing construction. St-Hilaire C used big data methods to explore the degree of financialization of property ownership, combined with property evaluation, commercial registration, and rental advertising data, revealing different types of financialization of rental housing in Montreal. Financial ownership is found to be related to housing pressure and intensive housing, with two patterns characterized by unstable or affluent tenants [1].Bower M believed that COVID-19 has amplified housing inequality in Australia, leading to damage to mental health. Research has found that the housing environment is closely related to mental health, and a lack of space and quiet environment can increase anxiety and loneliness [2]. Ryan-Collins J proposed the concept of "leasing", emphasizing the transformation of housing as an asset [3].

Hankinson M's research indicates that the impact of local election rules in the United States on ethnic minorities has not received sufficient attention. California's electoral reform has led to a decrease in new housing permits, especially in segregated cities inhabited by ethnic minorities [4]. Ebekozien A investigated the obstacles to green buildings in public hospitals in Nigeria and proposed policy solutions. Virtual interviews revealed obstacles related to six themes: government policies, organizational leadership, finance, technology, design teams, and stakeholder behavior. The research results indicate that adopting policies targeting these obstacles may help improve hospital green buildings [5]. Yang J K established a quantitative driving index by evaluating the driving forces of green building implementation in Vietnam. He used the fuzzy comprehensive evaluation method to develop the driving index (DI) for green buildings in Vietnam. The results show that environmental impact is the most critical factor. This provides decision-makers with a comprehensive tool to evaluate the expected implementation of green buildings in developing countries [6].

Chadly A quantified the economic performance risks of energy storage system (ESS) applications in buildings and examined the performance of lithium-ion batteries, proton exchange membrane reversible fuel cells, and reversible solid oxide batteries in different climate regions. The results show that the cost of capital is the largest cost factor, and the LCOS (levelized cost of energy storage) model is affected by input parameter uncertainty [7]. Ramu K explored a solution to replace halogen flame retardants with non halogen green building materials and proposed a method of direct contact between additives and building materials to provide long-lasting flame retardancy.

The results showed that the Tarong scheme ranked first in terms of net advantage and ranking, followed by Gladstone, Port Augusta ranked second, and Collie ranked third [8].

Rathnasiri P aimed to provide a framework for implementing green BIM (Building Information Modeling) technology in existing buildings in Sri Lanka. He adopted a qualitative research method, selected two existing buildings for multi case studies, designed BIM models using Autodesk Revit, and conducted solar and energy analysis using Green Building Studio simulation software. The research results show that green BIM technology has enormous potential for application in existing buildings, but faces challenges such as insufficient data [9]. Ercan E used recycled peanut shells to produce particleboard to protect forest resources and promote green building design. The test results show that peanut shells can delay combustion time, increase combustion temperature, and reduce formaldehyde release [10]. Jiang H explored the institutional complexity of China's green housing transformation from a multi-level perspective and reveals their attitudes and motivations through surveys of developers. The results show that policy and market institutional changes are crucial for promoting the normalization of green building practices, while the driving force of financial or technological institutions is relatively small [11]. Doan D T evaluated the benefits, obstacles, and solutions for integrating Green Star and BIM in New Zealand. He found through a questionnaire survey of 77 architectural professionals that building performance modeling evaluated by Green Star can be achieved through BIM, which is the biggest advantage. The main obstacle is that they are two completely independent processes. Among the solutions, the BIM Green Star benchmark project is considered the most effective [12]. Bradu P introduced the importance of green technology (GT) and Industrial Revolution 4.0 [13].

According to a survey conducted by Chen L, the construction industry accounts for 36% of global energy consumption and 39% of carbon dioxide emissions. It is necessary to achieve net zero carbon emissions by 2050. The construction phase accounts for 20-50% of carbon emissions throughout the lifecycle of buildings. The policy framework and technical roadmap cover the United States, Japan, China, and the European Union, with a focus on plans to achieve carbon neutrality in construction [14]. Wang Q used provincial panel data in China and found a positive correlation between traditional and demand side environmental regulations and green buildings, but the Chinese National Standards Committee and state-owned enterprises negatively moderated this relationship [15]. Han X outlined the concept of green interior design and emphasized its role, principles, and key applications in interior design [16]. Najjar M K reviewed the application of life cycle assessment in the construction field, with a particular focus on energy efficiency estimation and terminal impact assessment for concrete and steel structures. Case studies have shown that steel structures have advantages in environmental protection compared to concrete, encouraging the adoption of innovative technologies in production to achieve resource conservation and environmental protection [17]. The existing research on new residential models and housing construction has multiple shortcomings, including limited research scope, lack of on-site verification, neglect of social and economic factors, insufficient sustainability assessment, and lack of comprehensive research methods.

3. Methods

3.1. Research Object

Due to the geographical environment, the residential buildings in Guanzhong can be divided into two types in terms of construction methods: the first type is the courtyard style houses in the Guanzhong Plain area; Another type is kiln dwelling houses, which are mainly distributed in the Loess Plateau and Loess Gully areas, and are less distributed in Guanzhong.

According to the development stages of Guanzhong dwellings, they can be divided into three development periods. Firstly, before the 1980s, the development of dwellings still maintained tradition. Its construction techniques mainly use local building materials and simple, low-cost, and low tech construction. The functional space of residential buildings presents a single and comprehensive feature, and draws inspiration from the prototype of Guanzhong residential buildings for replacement and deformation, in order to achieve low comfort. The second period was from the 1980s to the 1990s, accompanied by the wave of reform and opening up, there was a boom in residential construction. Building materials such as clay bricks, cement, and tiles quickly became popular, which had an impact on the inheritance of residential buildings; The third period is the first decade of the 21st century, accompanied by social and economic development, a new wave of residential construction has emerged, but it has also brought a series of housing problems. How to inherit the architectural wisdom and organically combine it with new materials and technologies under the unique economic conditions, production systems, and architectural structures of rural China is an urgent issue that needs to be solved [18].

3.2. External Characteristics of Traditional Residential Buildings in Guanzhong

Traditional Chinese housing exhibits rich spatial elements and combination relationships, which are not only the characteristics of the building itself, but also the understanding and requirements of human beings for residential space. Firstly, this article analyzes the spatial composition factors of traditional residential buildings in Guanzhong, from three aspects: street and alley orientation, housing layout, and architectural layout. The houses in this area are often divided into east houses, north houses, south houses, and west houses according to the direction of the road. Siheyuan is a common layout, usually along the street, with a combination of inverted seats, main rooms, and two entrances, as well as a combination of main rooms, foyer, and two entrances. The north roof faces south, creating a special spatial form. Secondly, the spatial integration relationship of traditional dwellings was demonstrated from two aspects: "inter" and "in". "Space" is the most basic spatial unit in wooden structures, which is formed by connecting two roof trusses and is also the most distinctive constituent element. "Entering" refers to the effective combination of various courtyards, reflecting the orderliness of living space. By adjusting the amount of incoming light and layout, it can adapt to the needs of various purposes and achieve spatial flexibility.

3.3. Qualitative Analysis of Green Experience in Traditional Residential Buildings in Guanzhong

3.3.1. At the Level of Village Planning

The planning of village site selection is an important task at the beginning of residential construction. Influenced by factors such as natural environment, religious rituals, and feng shui culture, traditional settlements often have mountains and water on their backs to avoid the cold wind in the northwest during winter and obtain a cool water and land breeze in summer. Village planning is often designed from three aspects: landscape pattern, form layout, and intersection types of streets and alleys.

3.3.2. Landscape Pattern

Guanzhong is located at the junction of the Northern Shaanxi Plateau and the Qinling Mountains. The historical and cultural village of Dangjia Village is built on the mountain. It is a typical valley-shaped village. Its unique geographical location makes it form a ”mountain—water—field—village—mountain" spatial layout, which can not only avoid the cold wind in winter, but also block the east-west light in summer, and regulate the microclimate in the village. Liufang Village is a typical ancient village. To the west is Liangshan Mountain and to the east is the Yellow River. It forms the structure of “mountain village-agricultural land-paddy field”. The village is close to the water source, which can not only meet people's daily life needs, but also form land and water winds in summer, which has a certain cooling function. Anwu Village is located on a plain, surrounded by a large area of cultivated land, and the main road runs through the village, forming a layout of “cultivated land—village—highway—village—cultivated land”. The village is surrounded by cultivated land, which is convenient for villagers to irrigate and cultivate, and it is also very convenient. In the process of urbanization, Jintiezhai Village is also surrounded by a large amount of cultivated land. The main road runs through the village, forming a “cultivated land—village—cultivated land—expressway” structure. The village is adjacent to the expressway and the farming area, with convenient transportation, convenient life and convenient travel.

4. Results and Discussion

4.1. Experiment Preparation

In order to have a more accurate understanding of the impact of various environmental factors in urban green space systems on urban green space systems, this article analyzed the green space systems in urban green space systems through expert questionnaire surveys. There were a total of 227 participants, including 140 in the architecture major, involving 24 architecture teachers, 15 architecture management personnel, 31 architecture design, 70 architecture students, and 87 other majors.

4.2. Experimental Results

Table 1: Summary of Architectural Teacher Questionnaire

Environmental Factors	Green Elements	Safety and Durability	Healthy and Comfortable	Convenience	Resource-Saving	Livable Environment	Impact
Natural Factors	Climatic Conditions	4	4	4	4	4	20
	Geography	4	4	1	4	4	17
Human Factors	Historical Evolution	1	1	1	1	1	5
	Lifestyle	1	4	4	4	1	14
	Production Methods	4	4	1	4	4	17
Social Factors	Construction Techniques	4	4	4	4	4	20
	Economic Level	4	4	4	4	4	20
	Social System	1	4	1	4	4	14
Degree Of Influence		23	29	20	29	26	

According to the impact data of environmental factors and green elements given in Table 1, it can be seen that climate conditions, geographical environment, and construction technology and economic level in social factors have a significant impact on urban green space systems, with a greater degree of influence. This indicates that in the planning and construction of urban green space systems, it is necessary to focus on and fully utilize the advantages of natural conditions and social factors, in order to improve the safety, health and comfort, living convenience, resource conservation, and environmental livability of urban green space systems. In addition, the historical evolution in human factors and the social system in social factors have a relatively small impact on the urban green space system. Therefore, it is necessary to pay more attention to the coordination and cooperation with natural and social factors in planning and construction to achieve comprehensive optimization of the urban green space system.

Table 2: Summary of questionnaires for objects familiar with green buildings

Environmental factors	Green Elements	Safety and Durability	Healthy and Comfortable	Convenience	Resource-saving	Livable Environment
Natural Factors	Climatic conditions	√	√	√	√	√
	Geography	√	√	√	√	√
Human Factors	Historical Evolution	√	×	×	×	×
	Lifestyle	×	√	√	√	√
	Production methods	√	√	×	√	√
Social Factors	Construction techniques	√	√	√	√	√
	Economic level	√	√	√	√	√
	Social system	×	×	√	√	√

From the data in Table 2, it can be seen that natural and social factors have a greater impact on the green elements of cities, while the impact of human factors is relatively small. Therefore, in the planning and construction of urban green development, it is necessary to fully consider and utilize the advantages of natural and social factors to enhance the level of green elements in the city.

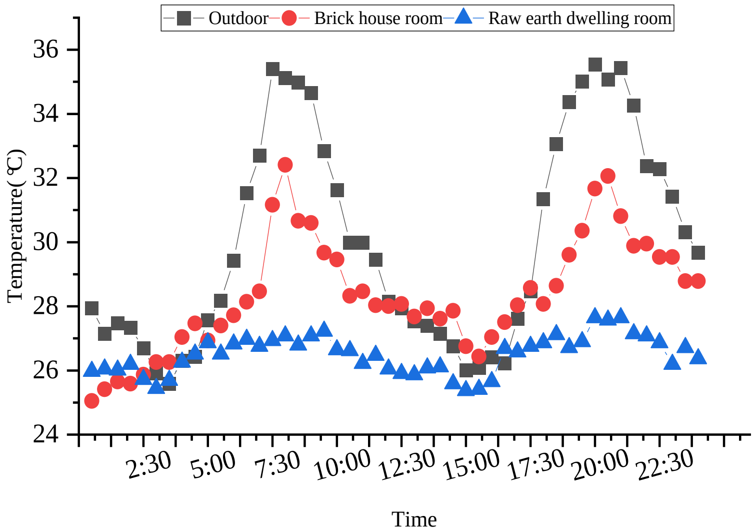

Figure 1: Temperature curves of brick and concrete residential rooms, raw soil residential rooms, and outdoor areas in summer

From Figure 1, it can be seen that the temperature in the room of the raw earth residential building is relatively low, and the temperature change amplitude is small. Although the heating rate of brick and concrete residential rooms has a certain delay compared to the outdoors, which has a thermal insulation effect, the effect is not significant.

The reason for this is that the exterior walls of the raw earth residential buildings are thick rammed earth walls, with smaller windows and a sloping roof. The roof is composed of a combination of local grass, mud, and green tiles, and there is a thick insulation layer between the roof and the sloping roof. The construction method of adobe houses will greatly block the indoor environment and greatly delay the arrival of outdoor temperature peaks. In addition, the vegetation around this adobe house is relatively good. Therefore, its absorption of solar radiation is much smaller than that of cement hardened flooring, and its secondary radiation to the surrounding environment and long wave scattering to the surrounding environment are also not significant.

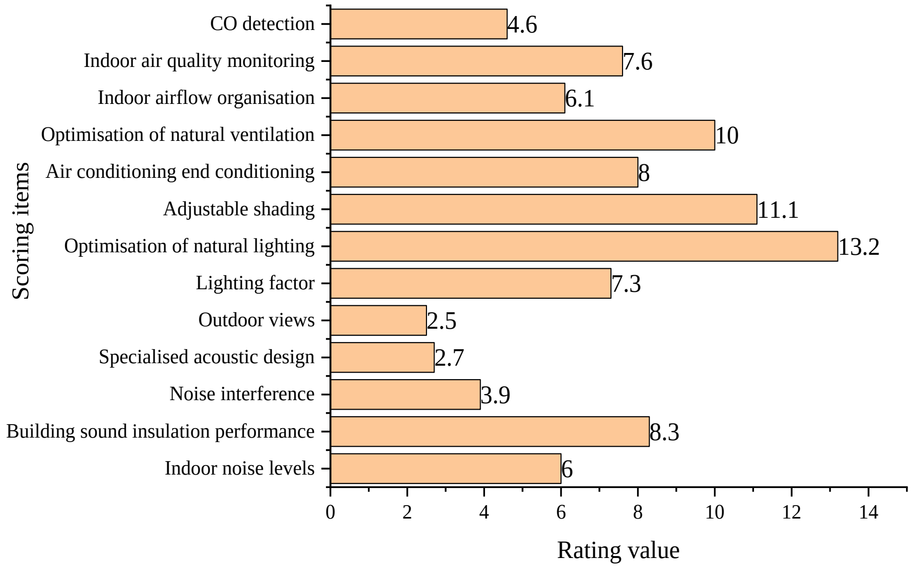

Figure 2: Indoor environmental quality evaluation items and their scores

According to the scoring items and their scores provided in Figure 2, the indoor environmental quality was evaluated. The scores for natural lighting optimization and adjustable shading are relatively high, with 13.2 and 11.1 points respectively, indicating good performance in lighting and shading. The scores for specialized acoustic design, outdoor vision, and indoor airflow organization are relatively low and need further improvement. Taking into account various scoring items, it is recommended to strengthen improvements in specialized acoustic design and CO detection to enhance indoor environmental quality. Therefore, in response to the current situation of indoor environmental quality in the Guanzhong area, the basic principle of "prioritizing passive technology and optimizing active technology" should be followed, fully utilizing the opening of door and window openings, wall and roof structural design, and the treatment of green landscape in the courtyard to create a system suitable for local residential greening design.

5. Conclusions

With the continuous intensification of global climate change and the rapid development of urbanization, green buildings have attracted much attention as an important means to promote sustainable development. In the Guanzhong region of China, as one of the regions with a long history and culture, traditional residential buildings carry rich historical and cultural heritage. However, facing the challenge of modern living needs, traditional residential buildings can no longer fully meet people's living needs. Therefore, studying how to combine the green wisdom of traditional residential buildings with modern green building concepts, and exploring new residential models that are in line with local climate, environment, and cultural characteristics has become one of the current research hotspots in the field of architecture in the Guanzhong region. The research on new residential models in the Guanzhong area integrates the green wisdom of traditional residential buildings with modern green building concepts. Through investigation and analysis, it is shown that residential buildings in the Guanzhong area perform well in natural lighting optimization and adjustable shading. However, there is room for improvement in specialized acoustic design and indoor airflow organization. Therefore, the principle of prioritizing passive technology and optimizing active technology should be followed, fully utilizing local natural conditions and traditional architectural wisdom, with the goal of improving indoor environmental quality and promoting urban green development. This can make efforts for the sustainable development of the Guanzhong region and the improvement of the quality of life of residents.

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