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The Evaluation National Green Building Index Based on a Survey of Personnel Satisfaction: The Case of Hubei Province, China

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Abstract: With the rapid development of China's urbanization process and the promotion of the 'double carbon' strategy, green buildings will become an inevitable trend in the future development of the construction industry. Among the various building evaluation criteria, it is important to discuss how to promote the development of green buildings more efficiently and adaptively according to the characteristics of personnel needs. This study constructed a questionnaire to assess building use satisfaction based on China's national standards. Field research was conducted on 23 projects in six cities in Hubei Province, China, and a total of 2251 questionnaires were collected. The survey evaluated satisfaction with the current use of green buildings across different age groups and genders. A new satisfaction evaluation model is constructed through fuzzy comprehensive evaluation to provide guidance for the differentiated development of green buildings in different cities.

Keywords: green building; personnel satisfaction; evaluation indicators; survey questionnaire; fuzzy comprehensive evaluation

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1. Introduction

The global urban population is expected to reach 68% by 2050 due to the acceleration of the urbanization process [1]. The construction industry is a rapidly growing sector, accounting for 40% of total global energy consumption [2,3]. In 2020, China pledged to 'peak carbon emissions by 2030 and achieve carbon neutrality by 2060' [4]. China's construction sector alone emits close to 2 billion tonnes of CO_2 annually [5]. According to reference [6], green buildings consume 25% to 30% less energy than traditional buildings. Therefore, developing green buildings is an effective way to reduce carbon emissions [7,8]. In 1990, the United Kingdom released the world's first green building assessment method, which brought green building assessment to the public's attention [9,10]. In comparison to traditional energy-saving buildings, green buildings offer greater advantages in energy conservation and emission reduction [11]. Currently, many countries have established a green building sustainable development evaluation system that aligns with their national conditions [12]. Mature green building technologies can effectively reduce the energy consumption of buildings [13,14]. Although green buildings offer more advantages than traditional buildings, they still face challenges such as technology, costs, and benefits [15,16]. Each national evaluation system has its own focus, but generally, it aims to promote environmental protection, energy efficiency, and sustainable development [9,17]. China's Assessment Standard for Green Building GB/T 50378-2019 (ASGB 2019) focuses on adapting to the country's environmental conditions, resources, and energy conditions, as well as residents' living habits [18]. It also emphasizes the applicability of residential and public buildings. Table 1 compares green building evaluation standards across different countries.

Table 1. Current status of green building evaluation standards in various countries.

Nation	Evaluation Criteria	Certification Level	Evaluation Aspect
China	ASGB 2019	Basic, One Star, Two Stars, Three Stars	The evaluation method is based on five green performance indices: safety and durability, health and comfort, convenience of life, resource saving, and livable environment.
America	LEED	Certified, Silver, Gold, Platinum	Evaluation criteria include sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality.
Britain	BREEAM	Pass, Good, Very Good, Excellent, Outstanding	The assessment covers management, health and well-being, energy, transport, water, materials, waste, land use and ecology, and pollution.
Japan	CASBEE	C, B−, B+, A, S	The evaluation indicators include the building's energy efficiency, material efficiency, indoor environment, etc.
Australia	NABERS	Between 0.5 and 6 stars, with 6 representing market-leading performance	The score is based on aspects such as energy consumption, water use, waste management, and indoor environmental quality.

Compared with developed countries, China's demand for green buildings remains high, with about 2 billion square meters of new commercial buildings added every year [19,20]. While learning from international experience, China's green building development also emphasizes the integration of traditional Chinese architectural culture, regionalism, adaptability, and the protection of cultural heritage [21]. In 2005, China's former Ministry of Construction and Ministry of Science and Technology jointly issued the 'Green Building Technical Guidelines'. In accordance with China's national conditions and international building evaluation standards, the first edition of the Assessment Standard for Green Building (GB/T50378-2006) was promulgated in 2006. This standard provides a clear definition of 'green building' in China [22]. The standard evaluates the environmental performance of buildings in six categories: land use and outdoor environment, energy efficiency, water efficiency, material efficiency, indoor environmental quality, and operation management. It also establishes basic indicators [23,24]. In 2009 and 2010, two evaluation standards were implemented: Evaluation Standards for Green Industrial Buildings and Evaluation Standards for Green Office Buildings [25]. The 2014 second edition of the Assessment Standard for Green Building extended the scope of the standards to include all types of civil buildings. It also optimized and supplemented specific requirements [26]. In 2019, a new evaluation method was proposed based on five green performance indicators: safety and durability, health and comfort, convenience of life, resource saving, and livable environment [18]. China has developed a comprehensive system for green building standards that covers three levels: applicable object, applicable stage, and standard type [27]. Table 2 illustrates the development process of China's Assessment Standard for Green Building.

In 2019, China's total building area exceeded 500 billion square meters, with only 10% of it certified for green building [28]. By 2020, more than 77% of new civil buildings in cities and towns were green buildings [29]. In 2021, China's green buildings increased by 2.362 billion square meters, and the proportion of new green buildings reached 84.22% of the annual new buildings [30]. In accordance with green building evaluation requirements, buildings must meet green building grade standards while fulfilling their general use functions throughout their entire life cycle [31]. Despite the rapid development of China's green building industry in recent years, there are still issues with meeting expected outcomes [32].

Therefore, it is important to consider the specific needs of occupants when designing the architecture comprehensively [33].

Table 2. Development process of China's Assessment Standard for Green Building.

Edition	Evaluation Opportunity	Evaluation Content	Evaluation Principle	Technical Requirement	Individuation
2006	Post-construction	Operation evaluation	/	/	/
2014	After the design, after the construction is completed	Design evaluation, operation evaluation	/	/	/
2019	After the construction drawing design is completed (pre-evaluation), upon completion of the building	Pre-evaluation, operational evaluation	Four sections and one environmental protection, people-oriented	More detailed and comprehensive	Pay attention to regional differences

At present, whether the comfort of Chinese buildings and the surrounding living environment meet people's growing needs for a better life has become the focus of current green building development. However, in ASGB 2019, all evaluation indicators are evaluated using the same system, which inevitably reduces the pertinence of building use functions and fails to reflect the impact of evaluation indicators on life satisfaction [34]. Therefore, it is necessary to evaluate and improve the indicators in the green evaluation standard according to the needs and satisfaction of personnel.

Hubei Province is situated in the heartland of China and is a typical central region [35]. The winter temperature in most areas ranges from 3 °C to 5 °C, while the summer temperature ranges from 26 °C to 29.5 °C. The average annual precipitation is 1200.7 mm, and the climate is characterized by hot summers and cold winters. Therefore, buildings require both cooling in summer and heating in winter, resulting in high energy consumption demands. It is important to understand the needs of users [36]. With the development of the economy, Hubei Province has become an important transportation hub in China, leading to a sharp increase in population and demand for buildings. This paper aims to comprehensively assess people's use and demand for green building functions in Hubei Province, China. To achieve this, we use the satisfaction degree of existing green building users in Hubei Province as an indicator, following the guidelines set out in ASGB 2019. This study focuses on public and residential buildings. A satisfaction evaluation model was developed using the analytic hierarchy process, based on questionnaire surveys and statistical analysis. The weight of the satisfaction index of residential buildings was calculated, and the weight ratio of each index in ASGB 2019 was compared. The research findings provide a valuable theoretical foundation for the current direction of green building development. The questionnaire survey uses a five-level scale, with the first- and second-level index questions compiled based on the scoring items in ASGB 2019. This paper focuses on two main issues: (1) This report evaluates the satisfaction levels of the first-level index for both residential and public buildings, as well as their current functional status. (2) Additionally, it examines the weight distribution and satisfaction characteristics of secondary indicators for these types of buildings. The purpose of this evaluation is to identify indicators based on satisfaction and provide technical guidance and suggestions for the development of green buildings and the green transformation of existing buildings.

2. Investigation and Implementation

2.1. Survey Area

This survey involved research on a total of 6 prefecture-level cities in Hubei Province, including 9 public buildings and 14 residential buildings. Figure 1 shows the project distribution map, while Table 3 provides specific research project information and green building assessment time.

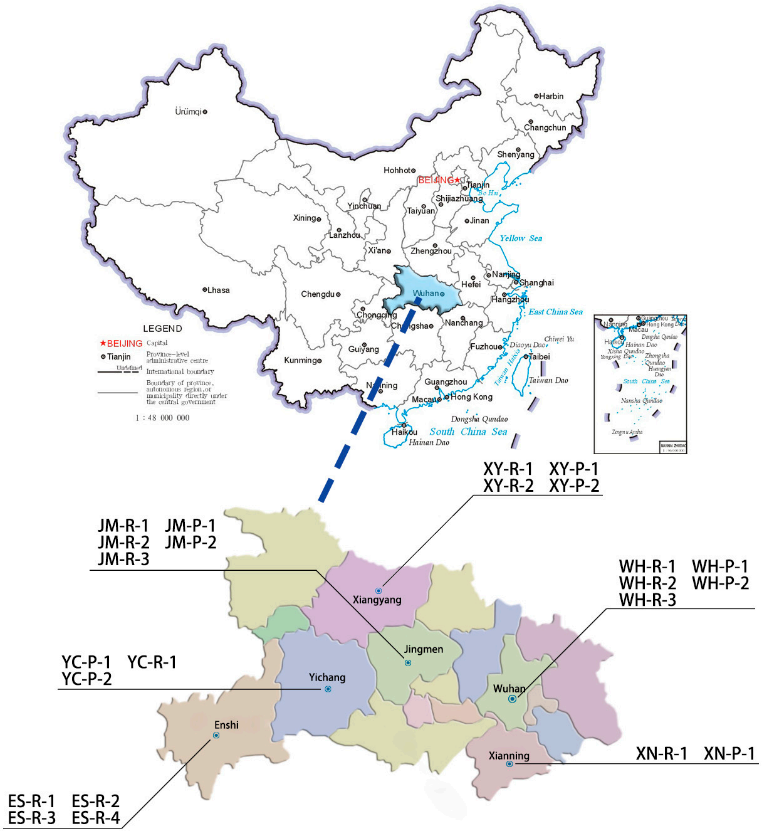


Figure 1. Project layout.

Table 3. Field research project information.

Project Location	Item Number	Project Name	Building Area (10^4 m^2)	Type of Building	Green Building Rating Time
Wuhan	WH-R-1	Building 1–10, Phase 8, Shimaolong Bay, Wuhan	25.65	Residential building	2020
	WH-R-2	Huafa Bund capital	11.99	Residential building	2020
	WH-R-3	Building 1~3, 5, Zhongjian Yi Pin LAN Hui, Wuhan	9.46	Residential building	2019
	WH-P-1	The new Hubei Science and Technology Museum	7.03	Public building	2019
	WH-P-2	Zhongcarbon Deng Building, Zhongbei Road, Wuchang District	7.85	Public building	2019

Table 3. *Cont.*

Project Location	Item Number	Project Name	Building Area (10^4 m^2)	Type of Building	Green Building Rating Time
Xiangyang	XY-R-1	Residential buildings No. 1~3, 7~8, 11~13, 15~19, Lot A1 "Dongjin Century City", Xiangyang	11.41	Residential building	2020
	XY-R-2	Residential building No. 1~3, 5~10, 15~17, 19~23, Lot A, PanggongBiyuan Project, Xiangyang	14.79	Residential building	2020
	XY-P-1	Laohekou public service comprehensive functional area	4.78	Public building	2019
	XY-P-2	Xiangyang Hubei Free Trade Zone Xiangyang Area Comprehensive Service Center project	0.99	Public building	2020
Enshi	ES-R-1	Blocks 1–3, 5–13, 15–17, Yubin Mansion, Country Garden	15.67	Residential building	2019
	ES-R-2	Building 1–3, 5 to 11, No. 9 Zhongliang Courtyard, Enshi	9.68	Residential building	2019
	ES-R-3	Building 21, Yipin Phase II, Enshi Capital	1.85	Residential building	2020
	ES-R-4	Building 6, Phase 3, Guangyin Haitangwan, Enshi	1.04	Residential building	2020
Yichang	YC-R-1	Building 1 to 3, 5 to 13, and 16, Area C, Country Garden Phoenix City, Yichang	16.47	Residential building	2020
	YC-P-1	Law enforcement and case handling site of Yichang Municipal Supervisory Commission	3.49	Public building	2019
	YC-P-2	Yichang Women's and Children's Activity Center	2.37	Public building	2019

Table 3. *Cont.*

Project Location	Item Number	Project Name	Building Area (10^4 m^2)	Type of Building	Green Building Rating Time
Xianning	XN-R-1	Building 1–3, 5, 7, 10, 11, Block A6, Ziwan International Resort, Xianning Greenland	11.22	Residential building	2020
	XN-P-1	Tongcheng County Yinshan Culture and Art Center (six halls, one hospital, and one venue) planning comprehensive hall	3.43	Public buildings	2020
Jingmen	JM-R-1	Residential building 1–7, Block 1, Longshan Central Business District, Jingmen	12.69	Residential building	2020
	JM-R-2	Commercial building No. 1–12, Lot 5, Longshan Central Business District, Jingmen	7.15	Residential building	2020
	JM-R-3	Building 1–17, Silver Lake City, Zhong Xiang	40.96	Residential building	2020
	JM-P-1	Jingmen Huijin Center Hotel Project	13.38	Public building	2020
	JM-P-2	Jingmen CPC Party School—Comprehensive building, lecture hall, lecture theatre, activity center	1.75	Public building	2019

2.2. Research Method

This study conducted a questionnaire survey on green building users in Hubei Province to assess their satisfaction with building use. A questionnaire survey was used as a research method:

(1) Determine research objectives and samples:

The survey aimed to evaluate satisfaction with the use of green buildings in Hubei Province. To ensure representative samples from different regions and building types, the investigation focused on users of residential and public buildings that have been rated as green buildings in the past five years in Hubei Province.

(2) Questionnaire design:

Questionnaire content: The design included basic user information (age, gender) and questions related to satisfaction with green building use. Questions were compiled according to key indicators in ASGB 2019.

Types of questions: The questionnaires were all compiled using a five-level satisfaction scale (e.g., on a scale of 1 to 5, from “very dissatisfied” to “very satisfied”) to rate different aspects of satisfaction.

(3) Distribution method:

A paper questionnaire and an online questionnaire were used to conduct the survey. Participants were selected for the survey using random sampling at the green building site. To ensure sample diversity and representativeness, project property management staff were authorized to issue online questionnaires to owners on their behalf. The deadline for online questionnaire collection was determined, and the data were organized and checked for integrity after collection. The photograph below displays the field research conducted on green buildings. For detailed information on the survey questionnaire, please refer to Appendix A. Figure 2 illustrates the research scenario, with Figure 2a–c representing typical buildings and Figure 2d–f depicting the distribution of survey questionnaires offline. Meanwhile, Figure 2g–i show the distribution of online questionnaires to property management personnel.

(4) Data analysis:

Figure 2. Architectural survey photos.

Statistical software was utilized to analyze data both descriptively and inferentially. The satisfaction results were analyzed, highlighting areas of high satisfaction and identifying areas for improvement. Based on the findings, specific recommendations were made to enhance the design and management of green buildings in China in the future.

2.3. Questionnaire Design

The questionnaire was compiled based on the ASGB 2019 in China, and some scoring items with high attention were selected. The survey was conducted through field visits to the star-rated buildings that passed the green building assessment in Hubei Province in 2019–2020, and the questionnaire was released in online and offline forms. Tables 4 and 5 show the questionnaire questions and corresponding index numbers.

Table 4. Questionnaire information for residential buildings.

Level 1 Index	Topic Number	Corresponding Specification Number	Level 2 Index
Safe and durable	SD-1-1	4.2.2	Balconies, outside windows, windowsills, protective railings, etc., have strengthened anti-fall design to reduce the risk of falling objects hurting people
	SD-2-1	4.2.4	Put anti-slip measures on the ground or pavement outside
	SD-3-1	4.2.5	Human–vehicle diversion, outdoor lighting effects
	SD-4-1	4.2.7	Original hardware fittings, pipe valves, switch taps, etc., are good-quality and easy to replace
	SD-5-1	4.2.8	Interior wall cracking
	SD-6-1	4.2.9	Building exterior paint fading, water seepage condition
Healthy and comfortable	HC-1-1	5.2.1	The indoor public space has a good ventilation effect and no odor
	HC-2-1	5.2.3	Outdoor landscape water is clean and pollution-free
	HC-3-1	5.2.4	Domestic water is clean and pollution-free
	HC-4-1	5.2.7	Indoor sound insulation effects
	HC-5-1	5.2.8	Indoor and basement lighting conditions
	HC-6-1	5.2.10	Indoor natural ventilation comfort
Live comfortably	LC-1-1	6.2.1	Accessibility to public transportation
	LC-2-1	6.2.2	The indoor and outdoor public areas of the building meet the requirements of all-age design
	LC-3-1	6.2.3	The surrounding area is equipped with corresponding public service facilities, such as hospitals and cultural centers
	LC-4-1	6.2.4	Open spaces such as urban green spaces, squares and public sports fields within walking distance
	LC-5-1	6.2.5	Set up a centralized outdoor fitness activity area
	LC-6-1	6.2.8	Real-time information on water use available online

Table 4. *Cont.*

Level 1 Index	Topic Number	Corresponding Specification Number	Level 2 Index
Environmental habitability	EH-1-1	8.2.2	Conditions for standing water outside during rainy weather
	EH-2-1	8.2.3	Comfort of greenery around this building
	EH-3-1	8.2.4	Reasonable setting of outdoor smoking areas
	EH-4-1	8.2.6	The noise level of the outdoor site
	EH-5-1	8.2.7	Outdoor light pollution levels
	EH-6-1	8.2.8	Comfort with natural ventilation outside
	EH-7-1	8.2.9	Outdoor shade comfort

This survey included public and residential buildings. Public buildings encompassed shopping malls, hospitals, and office buildings. The survey participants were of varying genders and ages, including teenagers (under 18 years old), youth (18–30 years old), prime age (31–50 years old), and elderly (over 51 years old).

The researchers distributed the offline questionnaire, and the project owners filled it out. On the other hand, the property management staff distributed the online questionnaire to the community owners or users of public buildings. This distribution strategy aimed to ensure that all participants were actual users of the current green buildings, thus ensuring the authenticity and reliability of the questionnaire results.

Table 5. Questionnaire information for public buildings.

Level 1 Index	Topic Number	Corresponding Specification Number	Level 2 Index
Safe and durable	SD-1-2	4.2.2	Balconies, exterior windows, windowsills, protective railings, etc., have strengthened anti-fall design to reduce the risk of falling objects hurting people
	SD-2-2	4.2.4	Put anti-slip measures on the ground or pavement outside
	SD-3-2	4.2.5	Human–vehicle diversion, outdoor lighting effects
	SD-4-2	4.2.7	Durability of equipment such as lighting, faucets, and plumbing in public areas
	SD-5-2	4.2.8	Use durable steel, anticorrosive wood, and other building materials
	SD-6-2	4.2.9	Indoor floor tiles have good wear resistance and low breakage rate
Healthy and comfortable	HC-1-2	5.2.1	Indoor public spaces are well ventilated and odor-free
	HC-2-2	5.2.3	Outdoor landscape water is clean and pollution-free
	HC-3-2	5.2.4	Domestic water is clean and pollution-free
	HC-4-2	5.2.7	Indoor sound insulation effects
	HC-5-2	5.2.8	Indoor and basement lighting
	HC-6-2	5.2.10	Natural ventilation comfort in the building during the transition season

Table 5. *Cont.*

Level 1 Index	Topic Number	Corresponding Specification Number	Level 2 Index
Live comfortably	LC-1-2	6.2.1	Accessibility to public transportation
	LC-2-2	6.2.2	The indoor and outdoor activity areas of the building meet the requirements of all-age design
	LC-3-2	6.2.3	The building has shared meeting facilities, fitness facilities, dining facilities, etc.
	LC-4-2	6.2.4	Open spaces such as urban green spaces, squares, and public sports fields within walking distance
	LC-5-2	6.2.5	Set up outdoor walking slow lanes
	LC-6-2	6.2.9	Mobile data network connection effect
Environmental habitability	EH-1-2	8.2.2	Conditions for standing water outside during rainy weather
	EH-2-2	8.2.3	Comfort of greenery around this building
	EH-3-2	8.2.4	Reasonable setting of outdoor smoking areas
	EH-4-2	8.2.6	Noise levels in outdoor activity areas
	EH-5-2	8.2.7	Outdoor light pollution levels
	EH-6-2	8.2.8	Comfort in natural ventilation outside
	EH-7-2	8.2.9	Outdoor shade comfort

2.4. Reliability and Validity Analysis

Upon completion of the survey, the reliability of the collected questionnaires was calculated to determine the reliability of the questionnaire data. The reliability of the questionnaire was determined using Cronbach's Alpha coefficient. A coefficient higher than 0.8 indicates high reliability, while a value between 0.7 and 0.8 indicates appropriate reliability. If the value falls between 0.6 and 0.7, it indicates that the data are available only after the questionnaire is modified. If the value is less than 0.6, it indicates low reliability and should be rejected. Equation (1) shows the reliability coefficient:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum S_i^2}{s_x^2}\right) \quad (1)$$

where α is the reliability coefficient; K is the number of test questions; S_i^2 is the variation of all subjects' scores on question i; s_x^2 is the variance of the total score of all subjects [37].

2.5. Correlation Analysis of Satisfaction

This questionnaire analyzes the preferences of different groups regarding the use needs of residential and public buildings based on their satisfaction. Factors such as gender and age of building users affect the demand for building use. The report proposes an analysis of the use needs of different groups of buildings based on their satisfaction and in accordance with ASGB 2019.

This study analyzed the correlation between sample variables and factors and investigated the relationship between gender and age and satisfaction and demand of each index using a *T*-test, one-way ANOVA, and chi-square test. The language used is clear, objective, and value-neutral, with a formal register and precise word choice. The text adheres to conventional structure and formatting features, including consistent citation and footnote style. The grammar, spelling, and punctuation are correct. No changes in content were made.

2.5.1. Independent Sample *T*-Test

The independent sample *T*-test is employed to compare the significance of the mean difference in continuous variables between two groups. In the case of two groups, the difference between gender and satisfaction is calculated, and the sample size and variance are taken into account to determine whether there is a significant difference in the mean.

The purpose of the independent sample *T*-test is to determine the probability of a difference occurring between two averages. Equation (2) is used to compare the difference between a sample average and a known population average to test for significance.

$$\mathrm{t} = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{(n_1-1)S_1^2+(n_2-1)S_2^2}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} \tag{2}$$

where S_1^2 and S_2^2 are the sample variances; n_1 and n_2 are the sample sizes; $\overline{X}_1$ and $\overline{X}_2$ are the sample averages.

2.5.2. One-Way Analysis of Variance

One-way analysis of variance is used to compare the means of continuous variables between multiple groups for statistically significant differences when there are multiple levels (groups) of an independent variable (the level of independent variable should be $\geq$3). By comparing the variation of age and satisfaction with the size of the variation within the group, it can be determined whether there is a significant difference in the mean value. The correlation test of personnel satisfaction involves the application of one-way ANOVA, which is calculated according to the following steps:

(1) The sum of the squares of the deviation of the overall data is SS_T. The specific calculation formula is as follows:

$$SS_T = \sum_{i=1,j=1}^{m,n}\left(x_{ij} - \overline{\overline{x}}\right)^2 \tag{3}$$

where x_{ij} is the result of any test; $\overline{\overline{x}}$ is the total average value of the test results.

(2) The sum of the squares of the difference between the groups is SS_A, indicating the degree of difference between the groups:

$$SS_A = \sum_{i=1}^{m}\left(\overline{x}_i - \overline{\overline{x}}\right)^2 \tag{4}$$

where $\overline{x}_i$ is the average value of test results in any group; the meanings of other parameters are the same as the preceding ones.

(3) The sum of the squares of the intra-group deviation SS_E represents the degree of difference within the group:

$$SS_E = \sum_{i=1}^{m}\sum_{j=1}^{n}\left(x_{ij} - \overline{x}_i\right)^2 \tag{5}$$

(4) To eliminate the effect of the number of samples on the sum of squares of deviation, divide the sum of squares of deviation by the corresponding number of degrees of freedom. The sum of the squared deviations between groups A is transformed into the variance between groups SS_A, as shown in the equation for MS_A:

$$MS_A = \frac{SS_A}{m-1} \tag{6}$$

where $m - 1$ is the degree of freedom of variance between groups; the meanings of other parameters are the same as the preceding ones.

(5) The sum of the squares of the intra-group deviations is converted to the intra-group variance MS_E:

$$MS_E = \frac{SS_E}{N - m} \tag{7}$$

where N is the total number of samples; that is, $m \times n$ and $n - m$ are the degrees of freedom of variance within the group; the meanings of other parameters are the same as the preceding ones.

(6) Finally, a statistic is used to test the significant influence of factors on the results, and F-distribution is used to test and analyze the results, as shown in Equation (8):

$$F = \frac{MS_A}{MS_E} \tag{8}$$

If the difference between samples has little effect on the detection results, then only random error affects the intra-group and inter-group variance, and the ratio will be close to 1.

If the difference between samples has a large impact on the detection result, then the inter-group variance will be greater than the intra-group variance, and the ratio will be greater than 1.

When this ratio is greater than a certain degree (F-test critical value), it indicates that there is a significant difference in the levels of different factors, or that factors have a significant impact on the results; in this case, the differences between different samples are too large and the samples are not uniform.

2.5.3. Chi-Square Test

The chi-square test is employed to compare whether there is a significant difference between the observed and expected values. It is suitable for analyzing categorical variables to test the correlation and independence between gender, age, and demand for each dimension. The test calculates the difference between the observed frequency and the expected frequency to determine whether the variables are correlated or independent. Once the theoretical and actual values have been obtained, the chi-square test can be performed. The significance of the difference is indicated by the chi-square value, with a smaller *p*-value indicating a more significant difference. A *p*-value of less than 0.05 (α level) indicates a significant difference. The calculation is as follows:

$$\chi^2 = \sum \frac{(A - T)^2}{T} \tag{9}$$

where χ^2 is the chi-square value; A is the actual value; T is the theoretical value.

2.6. Analytic Hierarchy Process

2.6.1. Construct Hierarchical Structure Model

AHP is an analytical method that converts qualitative data into quantitative data based on fuzzy comprehensive evaluation [38]. The method of fuzzy solution is used for calculation, but better results can be obtained with a large number of data samples [39]. The hierarchical structure model is constructed based on the original questionnaire design classification. Using the questionnaire as a hierarchical structure, identify the target layer, criterion layer, and index layer.

The judgment matrix is constructed, and the specific formula is as follows:

$$A = \left(b_{ij}\right)_{n \times n} \tag{10}$$

In the formula, b_{ij} is the indicator, and the importance scale of a_i and a_j relative to first-level indicators adopts the classical 1–9 scale method, and the quantization value k is shown in Table 6.

Table 6. The 1~9 scale method.

Factor a_i over Factor a	Quantization Value k
Equally important	1
Slightly important	3
Stronger important	5
Strongly Important	7
Extremely important	9
The middle of two adjacent judgments	2, 4, 6, 8
Count backwards	$b_{ij} = 1/b_{ji}$

The judgment matrix is computed by row $\overline{b}_j$, and the specific calculation formula is as follows:

$$\overline{b}_j = \prod_{i=1}^{n} b_{ij} \tag{11}$$

with quadrature heel $\overline{\omega}_i$.

$$\overline{\omega}_i = \sqrt[4]{\overline{b}_j} \tag{12}$$

Find the weight coefficient $\overline{\omega}_i$, which will be normalized to obtain ω_i.

$$\omega_i = \overline{\omega}_i / \sum_{i=1}^{n} \overline{\omega}_i \tag{13}$$

Solve for maximum feature root.

$$\lambda_{\max} = \sum_{i}^{n} ((A \times \omega)_i / n\omega_i) \tag{14}$$

where $(A \times \omega)_i = a_{i1}\omega_1 + a_{i2}\omega_2 + \ldots + a_{in}\omega_n$.

The weight vector is equal to the eigenvector ω corresponding to the largest eigenroot $\lambda_{\max}$ of matrix A.

2.6.2. Consistency Check

To construct the judgment matrix, a consistency test is needed to make the judgment result meet the basic consistency and order consistency.

To calculate the consistency index, see Equation (15):

$$CI = (\lambda_{\max} - n)/(n-1) \tag{15}$$

where CI is a consistency index.

The matrix average consistency index RI value is the query value used in the process of analytic hierarchy process consistency test and the average value obtained after 500 sampling tests by scientists, which is generally applicable to the judgment matrix consistency test. Table 7 shows the consistency indicator RI values.

Table 7. Average random consistency index.

Rank	4	5	6	7	8	9
RI value	0.89	1.12	1.26	1.36	1.41	1.46

To calculate the consistency ratio, see Equation (16):

$$CR = CI/RI \tag{16}$$

When $CR < 0.1$, the judgment matrix is consistent and acceptable. On the contrary, when $CR \geq 0.1$, it is considered that the judgment matrix does not meet the consistency test and should be adjusted to maintain a certain degree of consistency [40].

3. Analysis and Discussion

3.1. Questionnaire Basic Information

A total of 2251 questionnaires were collected, comprising 1108 for residential buildings and 1143 for public buildings.

The needs of different gender and age groups for building use vary. For instance, the provision of commercial and social service facilities can help alleviate transportation issues for the elderly, enabling them to live more comfortably in the community [41]. Therefore, it is necessary to have a more comprehensive understanding of the satisfaction of various types of people with the existing buildings and the needs of the current buildings in terms of safety and durability, health and comfort, convenience of life, and livable environment. Table 8 presents the basic information of the respondents.

Table 8. Construction satisfaction survey.

Residential Buildings				Public Buildings			
Variables	**Options**	**Frequency**	**Percentage**	**Variable**	**Options**	**Frequency**	**Percentage**
Gender	male	479	43%	Gender	male	497	44%
	female	629	57%		female	646	57%
Age	Under 18	32	3%	Age	Under 18	35	3%
	18–30	701	63%		18–30	725	63%
	31–50	346	31%		31–50	356	31%
	51+	29	3%		51+	27	2%
1108 in total				1143 in total			

The survey was conducted both online and offline. The respondents were predominantly middle-aged and young, with a slightly higher proportion of women than men.

To ensure the reliability of the results, measures were taken to reduce the impact of accidental factors, such as measurement errors, that could cause the respondents' actual scores to deviate from their true scores. To evaluate the reliability of the questionnaire, reliability and validity coefficients are used.

Figure 3 shows the reliability coefficients for both residential and public buildings. Based on the reliability analysis results, it is evident that the standardized reliability coefficients of both residential and public buildings are greater than 0.7 for safety and durability, health and comfort, convenience of life, livable environment, and overall sub-items, indicating good relative reliability.

Figure 3. Reliability coefficient.

Table 9 displays the validity calculation outcomes for both types of buildings.

Table 9. Analysis of KMO and Bartlett *T*-test.

	Residential Buildings		Public Buildings	
KMO sampling appropriateness measure		0.971		0.972
Bartlett's sphericity test	Approximate chi-square Degree of freedom Salience	12,237.473 300 0	Approximate chi-square Degrees of freedom Salience	12,130.045 300 0

According to the results of the above exploratory analysis, it can be seen that the coefficient results of the KMO test are all greater than 0.9, and the value of the coefficient of the KMO test ranges from 0 to 1. The closer the coefficient is to 1, the better the validity of the questionnaire.

According to the significance of the sphericity test, it can also be seen that the significance of this time is infinitely close to 0, so the null hypothesis is rejected. Therefore, the questionnaire has good validity.

3.2. Evaluation Index Satisfaction Difference Analysis

3.2.1. Level 1 Index Satisfaction

Table 10 shows the gender differences in satisfaction.

Table 10. Analysis of gender differences in satisfaction (independent sample *T*-test).

Variables	Gender	Number of Cases		t		sig	
		Residential Building	Public Building	Residential Building	Public Building	Residential Building	Public Building
Safety and durability satisfaction	male female	479 629	497 646	0.355	1.197	0.723	0.231
Health comfort satisfaction	male female	479 629	497 646	0.210	1.338	0.834	0.181
Convenience satisfaction	male female	479 629	497 646	0.151	1.156	0.880	0.248
Environmental habitability satisfaction	male female	479 629	497 646	0.166	0.815	0.868	0.415

According to the results of the *T*-test of the above independent samples, it can be seen that the gender difference in the satisfaction of all dimensions of residential buildings and public buildings is greater than 0.05, indicating that there is no gender difference in the satisfaction of safety and durability, health and comfort, convenience of life, and livable environment.

Based on the results of multiple comparisons presented in Table 11, it is evident that individuals aged 31–50 report higher levels of satisfaction with regard to safety and durability, health and comfort, convenience of life, and livable environment compared to those aged 18–30. Young people may prioritize quality of life, leading to higher standards for residential buildings. In contrast, middle-aged individuals tend to prioritize functional demand for green buildings and may not prioritize quality and functionality as much as younger individuals. Compared to residential buildings, public buildings provide greater satisfaction in terms of health and comfort for those aged 18–30 and 31–50, compared to those over 51 years old. Additionally, satisfaction levels are higher for those aged 18–30 compared to those over 51 years old, and for those aged 31–50 compared to those under 18 and over 51 years old. Public buildings primarily serve middle-aged and young people, who value convenience, health, and comfort. The current public buildings have successfully prioritized these aspects.

Table 11. Difference analysis of satisfaction with age in each dimension (one-way analysis of variance).

Variables	Options	Number of Cases		t		F		Multiple Comparisons	
Types of Satisfaction	Age Group	Residential Building	Public Building	Residential Building	Public Building	Residential Building	Public Building	Residential Building	Public Building
Safety and durability satisfaction	Under 18 18–30 31–50 Age 51+	32 701 346 29	35 725 356 27	0.355	1.197	5.819	2.452	3 > 2	/
Health comfort satisfaction	Under 18 18–30 31–50 Age 51+	32 701 346 29	35 725 356 27	0.210	1.338	3.564	3.120	3 > 2	2 > 4, 3 > 4
Satisfaction with convenience of life	Under 18 18–30 31–50 Age 51+	32 701 346 29	35 725 356 27	0.151	1.156	4.329	4.469	3 > 2	2 > 4, 3 > 1, 3 > 4
Environmental habitability satisfaction	Under 18 18–30 31–50 Age 51+	32 701 346 29	35 725 356 27	0.166	0.815	5.318	2.154	3 > 2	/

In addition to the four categories of safety and durability, health and comfort, convenience of life, and livable environment, the questionnaire adds specific evaluations of these four categories in terms of their greater impact on life, better functional realization, and need to be improved.

Table 12 displays the distribution of subjective feelings across the various categories. Based on the results, 52.3% of residents believe that health and comfort have a greater impact on their lives, while 39.1% believe that their current living environment provides adequate health and comfort. Safe and durable and convenient life were ranked second, while environmental habitability was ranked the lowest. Similarly, the demand for health and comfort is significantly higher than the other three factors in terms of function. The proportion of health and comfort in public buildings' impact on life is 48.5%, the proportion of function realization is 39.2%, and the proportion of improvement is 42.3%, all of which exceed the other four factors. This indicates that public buildings play a crucial role in people's lives. Meanwhile, with regard to convenient life, 32.9% of respondents believe that the function is superior.

Table 12. The distribution of people's subjective feelings in each category.

Variables	Categories	Frequency		Percentage	
		Residential Buildings		Public Buildings	
Life impact situation	Safe and durable	208	18.80%	264	23.10%
	Healthy and comfortable	579	52.30%	554	48.50%
	Ease of living	229	20.70%	247	21.60%
	Environmental habitability	92	8.30%	78	6.80%
Function implementation	Safe and durable	254	22.90%	258	22.60%
	Healthy and comfortable	433	39.10%	425	37.20%
	Convenience of living	329	29.70%	376	32.90%
	Environmental habitability	92	8.30%	84	7.30%
Need to improve	Safe and durable	266	24.00%	263	23.00%
	Healthy and comfortable	437	39.40%	483	42.30%
	Convenient living	257	23.20%	241	21.10%
	Environmental habitability	148	13.40%	156	13.60%

A chi-square test was conducted on the data from the aforementioned questions to analyze the correlation between different needs, gender, and age. The results of the calculations are presented in Table 13.

Table 13. Difference analysis of correlation degree between different demands and variables (chi-square test).

Variables	Factors	χ^2	
		Residential Building	**Public Building**
Gender	An analysis of gender differences in the impact of different dimensions on life	0.001	0.047
	Age difference analysis of functional realization perception in each dimension	0.070	0.075
	Gender difference analysis of functional improvement in each dimension	0.584	0.307
Age	An analysis of the differences in the impact of various dimensions on life in age	0.435	0.760
	Analysis of the difference in functional realization experience in each dimension in age	0.582	0.002
	Age difference analysis of functional improvement in each dimension	0.178	0.895

Residential and public buildings exhibit significant differences in the importance of four dimensions of life impact based on gender. Men place a higher demand for safety and durability on both types of buildings compared to women. This suggests that men prioritize practicality and pay more attention to the safety and durability of buildings.

In residential buildings, there is no obvious difference in the demand and satisfaction of different age groups for the realization of green building functions. There are significant differences in the functional realization of all dimensions of public buildings by age. People between 31 and 50 years old have the lowest perception of the realization of safety and durable functions, while people in this age group feel better in terms of health and comfort. People in the age group of 31–50 have more frequent contact with public buildings in daily life. Compared with the safety of public buildings, they have more obvious feelings about the use of buildings. Whether there are problems in the safety and durability of public buildings is the next step to discuss.

3.2.2. Level 2 Index Satisfaction

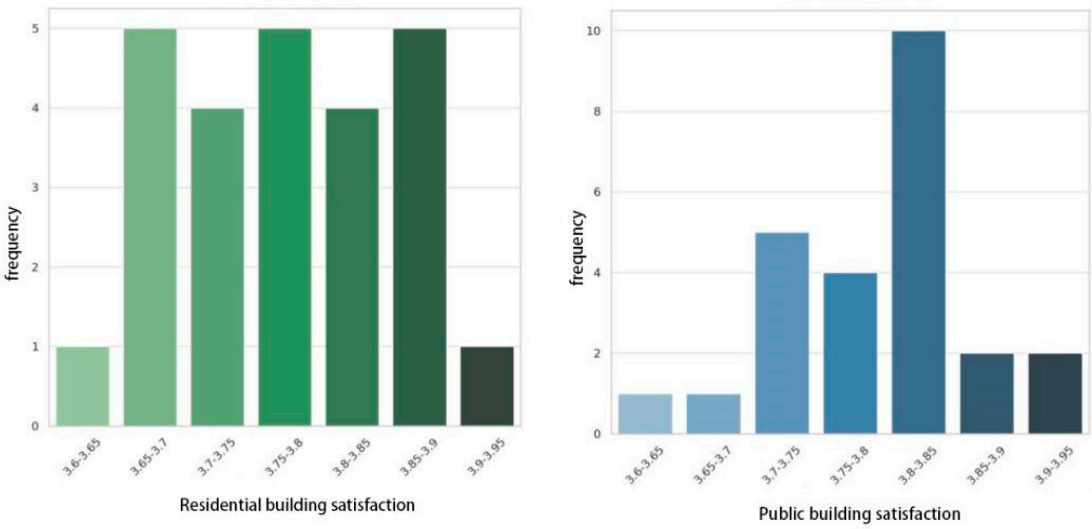
The following table (Table 14) shows the average satisfaction scores of residential buildings and public buildings in the survey.

To visually display the distribution of satisfaction levels in green building use, a bar chart has been chosen to represent the frequency distribution across different satisfaction intervals. The bar chart allows for a quick comparison of frequencies between intervals, identifying which intervals have higher or lower satisfaction levels. This analysis examines the distribution of satisfaction by analyzing the satisfaction intervals and the frequency of residential and public buildings within these intervals.

In Figure 4, the first picture shows the satisfaction level of residential buildings, and the second picture shows the satisfaction level of public buildings. The satisfaction distribution of residential buildings is concentrated in the range of 3.65–3.8, with the highest frequency being 3.65–3.7 and 3.75–3.8. In contrast, the satisfaction distribution of public buildings in the 3.8–3.85 interval is significantly higher than that in other intervals, indicating that users in this interval are more satisfied.

Table 14. Average score of satisfaction with secondary indicators.

Residential Building Index	Average Score	Public Building Index	Average Score
SD-1-1	3.867	SD-1-2	3.893
SD-2-1	3.731	SD-2-2	3.720
SD-3-1	3.776	SD-3-2	3.815
SD-4-1	3.776	SD-4-2	3.824
SD-5-1	3.656	SD-5-2	3.808
SD-6-1	3.670	SD-6-2	3.833
HC-1-1	3.887	HC-1-2	3.917
HC-2-1	3.760	HC-2-2	3.748
HC-3-1	3.874	HC-3-2	3.884
HC-4-1	3.648	HC-4-2	3.647
HC-5-1	3.681	HC-5-2	3.733
HC-6-1	3.860	HC-6-2	3.841
LC-1-1	3.910	LC-1-2	3.927
LC-2-1	3.714	LC-2-2	3.696
LC-3-1	3.789	LC-3-2	3.780
LC-4-1	3.853	LC-4-2	3.817
LC-5-1	3.732	LC-5-2	3.830
LC-6-1	3.727	LC-6-2	3.837
EH-1-1	3.782	EH-1-2	3.758
EH-2-1	3.822	EH-2-2	3.768
EH-3-1	3.662	EH-3-2	3.706
EH-4-1	3.672	EH-4-2	3.706
EH-5-1	3.812	EH-5-2	3.777
EH-6-1	3.830	EH-6-2	3.815
EH-7-1	3.823	EH-7-2	3.820



(**a**) (**b**)

Figure 4. Distribution interval of satisfaction.

In Figure 4, subfigure a represents the distribution of satisfaction with residential buildings, and subfigure b represents the distribution of satisfaction with public buildings. When comparing the satisfaction distribution of residential and public buildings, it is found that residential buildings have six indicators of low satisfaction, with an average satisfaction score lower than 3.7, while public buildings only have two. Among the indicators of high satisfaction above 3.9, residential buildings have six indicators and public buildings have four indicators. The user satisfaction of residential buildings is evenly distributed between 3.65 and 3.8, with scattered satisfaction scores. However, the user satisfaction of public buildings shows a clear central trend in the range of 3.8–3.85. Public buildings, as a whole, have a slightly higher satisfaction rating, indicating that most users tend to rate them highly. However, there is a need to enhance the architectural design of residential buildings and improve indicators with low satisfaction. This can be achieved by increasing the use of sound-absorbing materials to strengthen indoor sound insulation and enhancing the overall satisfaction of green buildings.

3.3. Weight Analysis of Evaluation Index Based on Personnel Satisfaction

The score of the questionnaire was scored in turn, the number of people was proportional, and the quantified value was converted according to the ki value. See Table 15 for an example of constructing a judgment matrix.

Table 15. Judgment Matrix (example).

Residential Building Satisfaction	Safe and Durable	Healthy and Comfortable	Convenient Life	Environmental Habitability	ω
Safe and durable	1	0.3333	0.5	2	0.1601
Healthy and comfortable	3	1	2	4	0.4673
Convenient life	2	0.5	1	3	0.2772
Environmental habitability	0.5	0.25	0.3333	1	0.0954

The consistency ratio of satisfaction of residential buildings is 0.0116; the weight of "residential building satisfaction" is 1.0000; $\lambda_{\max}$ is 4.0310. The satisfaction consistency ratio 0.0116 < 0.1, and the judgment matrix satisfies the consistency test.

Similarly, the two-level index judgment matrix was constructed, and a consistency test was carried out. The weight results of each classification of residential buildings are shown in Table 14.

The calculation formula of standard weight P_i is as follows:

$$P_i = \frac{P_n}{P_N} \tag{17}$$

where P_n is the single question score; P_N is the sum of question scores (the standard item score is the corresponding item score in ASGB 2019).

An evaluation function P is introduced as the weight ratio index.

$$P = \frac{P_i}{P_t} \tag{18}$$

where P_t is the Level 2 index weight.

The evaluation level P can be set as four evaluation levels: poor function realization ($P \leq 50\%$), functional implementation is mediocre ($50\% < P \leq 80\%$), the function is better ($80\% < P \leq 150\%$), the function is very good ($P < 150\%$). The calculation results are shown in the table below.

3.3.1. Residential Building

Figure 5 shows the weight of residential first-level indicators. In the subjective evaluation of owners, the subjective satisfaction of health and comfort is lower than the weight value calculated by the comprehensive calculation of each item, indicating that when the users of the building users use the building, the advantages of the building in health and comfort are not obvious, and the evaluation of the building in this aspect cannot be intuitively given. However, the subjective weight of safety durability is higher than the calculated weight, which shows that the current building performs relatively well in the stage from handover to operation and management.

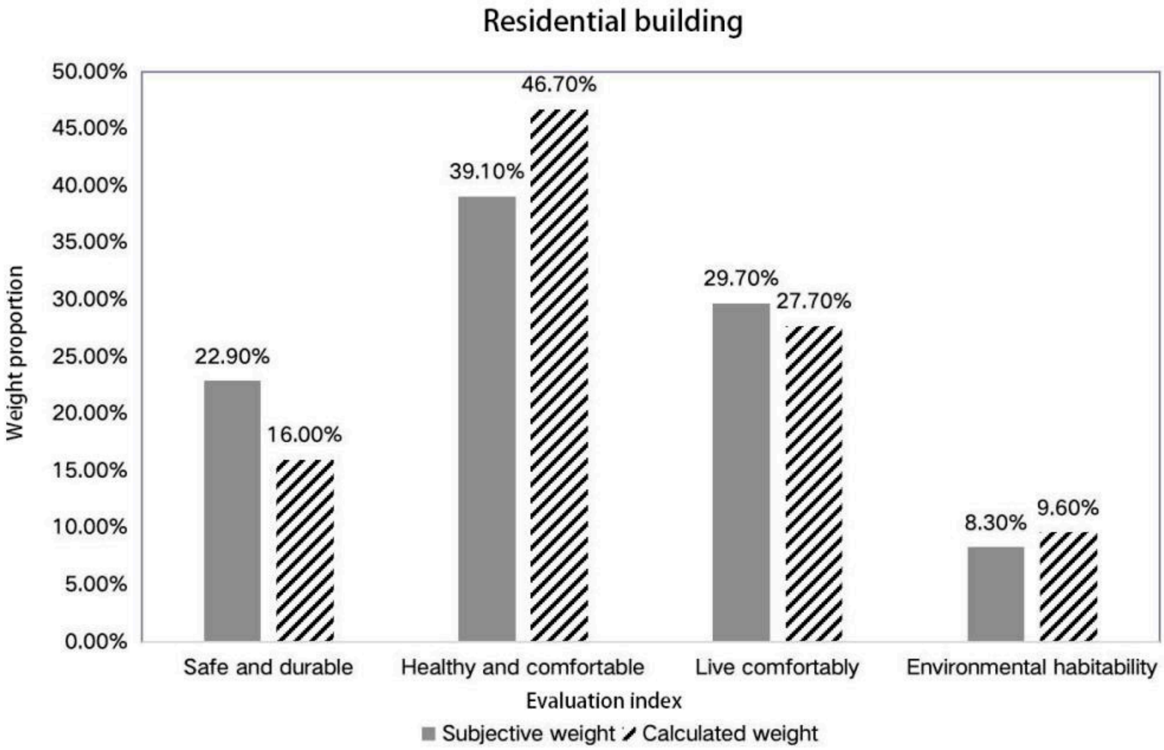


Figure 5. Level 1 index weight of residential buildings.

The proportion of the weight function of the secondary index is shown in Figure 6. The figure above presents the *p*-value for each factor. Based on the weight data, it is evident that personnel involved in residential construction are highly satisfied with indoor air quality, water safety, indoor natural ventilation comfort, convenience of public transportation, and open spaces such as cities and public venues within walking distance. These factors are represented as 'function realization is very good'. However, the level of satisfaction with indoor wall cracking, building exterior paint discoloration, water seepage, outdoor water accumulation, green comfort, outdoor smoking area provision, and noise and light pollution control is low, indicating poor functional realization. The satisfaction of outdoor ground non-slip surfaces, indoor sound insulation, lighting, outdoor fitness activity area setting, and surrounding public service facilities falls under the category of 'function realization is general'.

In terms of residential buildings, less than 50% of the standard of 85.3% of environmental livability has been achieved, indicating poor implementation in this field. In addition, 66.7% of the indicators exceeded 150% for health and comfort, which was the best performance among the four evaluation indicators. Convenience of life followed closely behind. Overall, it can be concluded that the evaluation system meets the objective requirements.

3.3.2. Public Building

The two-level index judgment matrix was constructed, and a consistency test was carried out. The weight results of each classification index of public buildings are shown in Table 16.

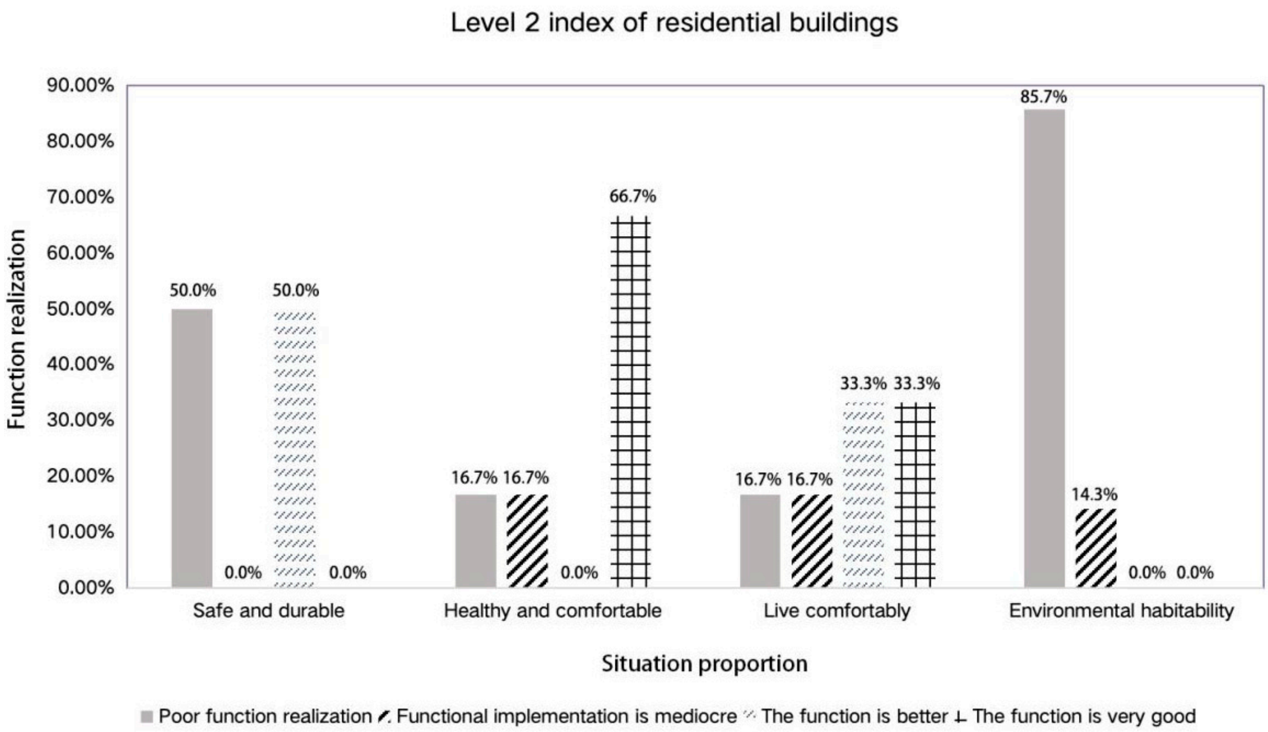


Figure 6. Level 2 index weight of residential buildings.

Table 16. Weights of evaluation indicators.

Level 1 Index	Level 1 Index Weight	Residential Building				Level 1 Index Weight	Public Building			
		Topic Number	Gauge Weight P_i	Level 2 Index Weight P_t	P		Topic Number	Gauge Weight P_i	Level 2 Index Weight P_t	P
Safe and durable	0.1601	SD-1-1	0.0615	0.0548	89.14%	0.1601	SD-1-2	0.0591	0.0603	102.11%
		SD-2-1	0.0410	0.0195	47.58%		SD-2-2	0.0394	0.0087	22.10%
		SD-3-1	0.0328	0.0329	100.35%		SD-3-2	0.0315	0.0141	44.77%
		SD-4-1	0.0410	0.0329	80.28%		SD-4-2	0.0709	0.0240	33.87%
		SD-5-1	0.0410	0.0079	19.28%		SD-5-2	0.0394	0.0141	35.81%
		SD-6-1	0.0369	0.0121	32.80%		SD-6-2	0.0354	0.0389	109.78%
Healthy and comfortable	0.4673	HC-1-1	0.0492	0.1751	356.04%	0.4673	HC-1-2	0.0472	0.1787	378.25%
		HC-2-1	0.0328	0.0648	197.64%		HC-2-2	0.0315	0.0470	149.23%
		HC-3-1	0.0369	0.0975	264.33%		HC-3-2	0.0354	0.1170	330.20%
		HC-4-1	0.0410	0.0192	46.85%		HC-4-2	0.0394	0.0200	50.80%
		HC-5-1	0.0492	0.0288	58.56%		HC-5-2	0.0472	0.0299	63.29%
		HC-6-1	0.0328	0.0819	249.80%		HC-6-2	0.0315	0.0746	236.86%
Live comfortably	0.2772	LC-1-1	0.0328	0.1044	318.42%	0.2772	LC-1-2	0.0315	0.1060	336.55%
		LC-2-1	0.0328	0.0150	45.75%		LC-2-2	0.0315	0.0119	37.78%
		LC-3-1	0.0410	0.0416	101.50%		LC-3-2	0.0394	0.0178	45.21%
		LC-4-1	0.0205	0.0674	328.91%		LC-4-2	0.0197	0.0279	141.73%
		LC-5-1	0.0410	0.0244	59.54%		LC-5-2	0.0394	0.0442	112.27%
		LC-6-1	0.0287	0.0244	85.05%		LC-6-2	0.0354	0.0694	195.86%
Environmental habitability	0.0954	EL-1-1	0.0410	0.0075	18.30%	0.0954	EL-1-2	0.0394	0.0062	15.75%
		EL-2-1	0.0656	0.0189	28.82%		EL-2-2	0.0630	0.0097	15.40%
		EL-3-1	0.0369	0.0033	8.95%		EL-3-2	0.0354	0.0039	11.01%
		EL-4-1	0.0410	0.0049	11.96%		EL-4-2	0.0394	0.0039	9.91%
		EL-5-1	0.0410	0.0117	28.55%		EL-5-2	0.0394	0.0150	38.10%
		EL-6-1	0.0410	0.0302	73.69%		EL-6-2	0.0394	0.0228	57.91%
		EL-7-1	0.0410	0.0189	46.12%		EL-7-2	0.0394	0.0338	85.85%

The Figure 7 indicates that the subjective satisfaction of health and comfort is lower than the weight value calculated by the comprehensive calculation of each item. This suggests that people's intuitive feeling of health and comfort is lower than the objective situation in the use of public buildings. It is evident that the current function of public buildings in health and comfort is relatively complete, exceeding the users' expectations. At the same time, the importance of safety, durability, and convenience in daily life outweighs that of mere calculation. It is evident that current public buildings have some shortcomings in these areas, which are noticeable and affect the users' experience.

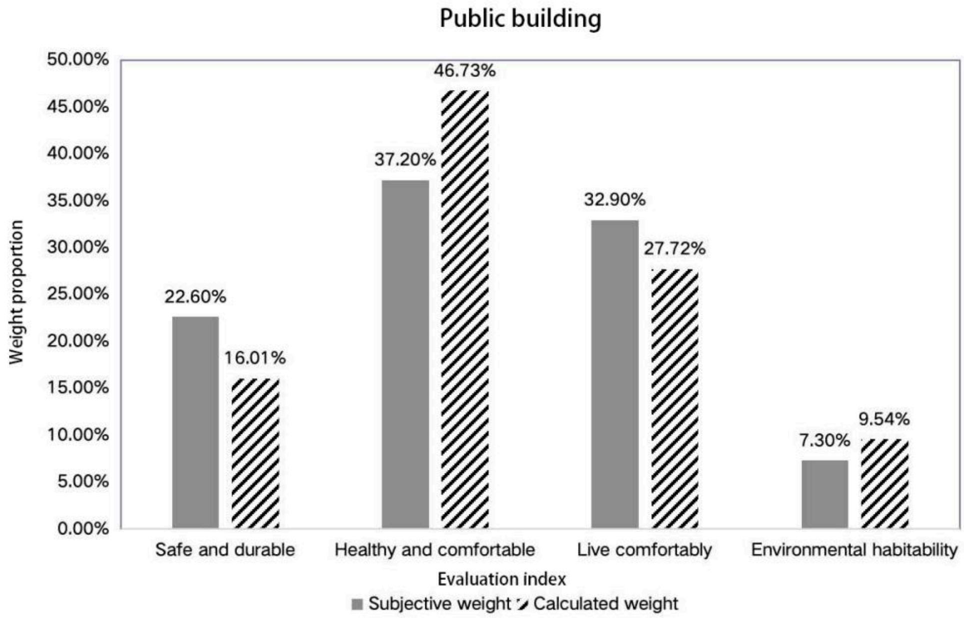


Figure 7. Level 1 index weight of public buildings.

Figure 8 shows the proportion of the implementation of the weight function of public secondary indicators. The figure shows the p-value for each factor. Based on the weight data, it is evident that public construction personnel are highly satisfied with indoor air quality, water safety, natural ventilation comfort, and the convenience of public transportation, with a 'good function realization' performance. However, they are less satisfied with outdoor water, green comfort, outdoor smoking area setting, and noise control, which fall under 'poor function realization'. Many other aspects of satisfaction fall somewhere in between.

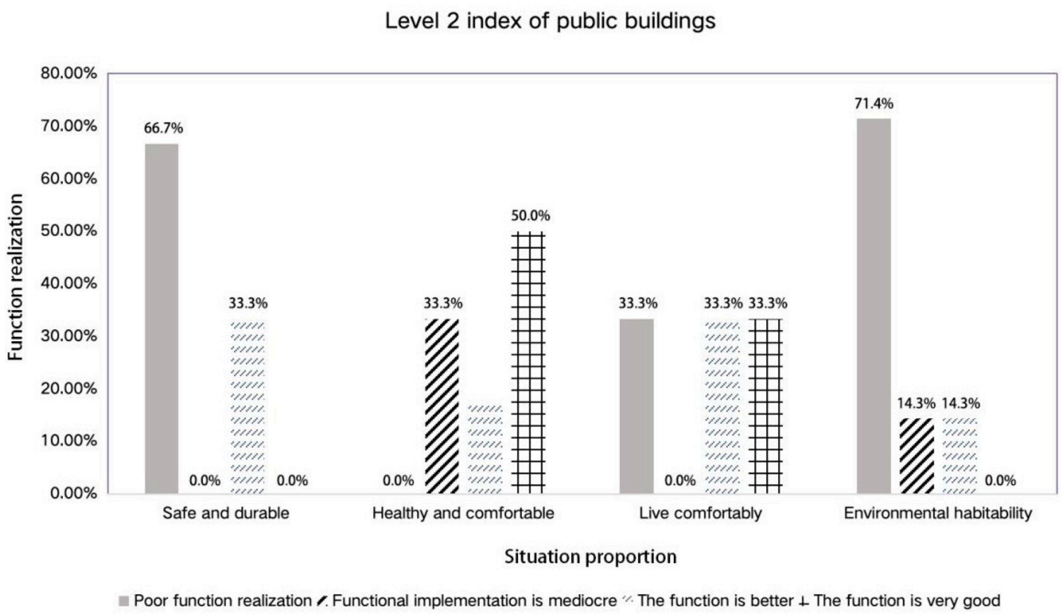


Figure 8. Level 2 index weight of public buildings.

Regarding safety durability and environmental livability of public buildings, 66.7% and 71.4% of the functional implementation standards are less than 50%, indicating poor implementation that needs improvement. As for health and comfort, 50% of the functional realization standards exceed 150%, indicating excellent performance. Meanwhile, in terms of living convenience, 33.3% of the indicators are better, and another 33.3% are rated as very good. This places it second only to health and comfort, indicating an overall positive effect of this factor.

4. Discussion

This study shows progress in the field of green building in China, particularly in terms of health and comfort, which are highly rated by building users. However, we have also observed that green buildings have some imperfections in certain functions, mainly in the areas of environmental livability and safety and durability, and user satisfaction is low in these two aspects. The future development of green buildings requires a better balance between various performance indicators. The study identified deficiencies in current green building technologies, including outdoor drainage after rainfall, the comfort of greenery around buildings, the layout of outdoor smoking areas, and outdoor noise control. Residential and public buildings exhibit a consistent trend in these key indicators, as evidenced by the weight of the indicators. It is apparent that certain indicators with low satisfaction require improvement.

Compared to the quantitative indicators in ASGB2019, this study offers a new perspective for understanding the needs of building users. It emphasizes that future green building designs should address the practical concerns of users more effectively. Hubei Province is located in the central region of China, making it both geographically representative and suitable for extending research results to a national scale. Additionally, this study presents a novel evaluation method that compares satisfaction weight with index weight in ASGB2019 to analyze the pros and cons of green buildings in a particular region. This provides a robust framework for differentiated green building development in the region. As a whole, this study enhances our comprehension of the user experience of green buildings and offers valuable insights to drive the continuous improvement of green buildings in China. This will help to further optimize the advantages of green buildings and address their shortcomings.

This research focuses on the content of building comfort in the current ASGB 2019 in China. However, there are still some limitations in this study, which did not investigate environmental performance, energy conservation, and carbon footprint. Therefore, it can be improved with follow-up research of this kind.

5. Conclusions

In summary, through an in-depth analysis of the satisfaction of existing green building users in Hubei Province, the following conclusions can be drawn:

(1) Health and comfort are the most important factors for users of residential buildings and public buildings, followed by convenience of life.
(2) Residential buildings and public buildings performed poorly in terms of livability, while health and comfort performed best.
(3) According to the average satisfaction, public buildings have a slightly higher overall satisfaction rating than residential buildings. However, some satisfaction indicators show that residential buildings have higher scores than public buildings. The sound insulation effect was rated lowest in both public and residential buildings.

Through this survey, we can more intuitively understand some problems existing in the current development of green buildings. In future green building design, it is important to prioritize the actual needs and satisfaction of users. Simultaneously, it is recommended that architectural designers focus on aspects with low user satisfaction while enhancing the overall performance of buildings. This will promote the development of green buildings in a more humanized and comfortable direction. Continuous optimization and adjustment are expected to lead to a higher level of green building development, achieving energy savings and emission reductions while providing residents with an improved living experience.

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Conflicts of Interest: Author Yinguang Wu was employed by the company Central-South Architectural Design Institute Co., Ltd. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Appendix A

Residential building questionnaire

Dear owner! In order to understand your actual needs, understand your service experience, in order to provide you with better service and experience later, I hope you fill in the following questionnaire according to your real ideas, thank you for your cooperation! Satisfaction scores range from low to high on a scale of 1–5.

Your gender: Male female

Your age: Under 18 18–30 31–50 51+

1. Balconies, outside Windows, windowsills, protective railings, etc. have strengthened anti-fall design to reduce the risk of falling objects hurting people. ( )
2. Put anti-slip measures on the ground or pavement outside. ( )
3. Human-vehicle diversion, outdoor lighting effects. ( )
4. Original hardware fittings, pipe valves, switch taps, etc., good quality and easy to replace. ( )
5. Interior wall cracking. ( )
6. Building exterior paint fading, water seepage condition. ( )
7. The indoor public space has good ventilation effect and no odor. ( )
8. Outdoor landscape water is clean and pollution-free. ( )
9. Domestic water is clean and pollution-free. ( )
10. Indoor sound insulation effects. ( )
11. Indoor and basement lighting conditions. ( )
12. Indoor natural ventilation comfort. ( )
13. Accessibility to public transportation. ( )
14. The indoor and outdoor public areas of the building meet the requirements of all-age design. ( )
15. The surrounding area is equipped with corresponding public service facilities, such as hospitals, cultural centers, etc. ( )
16. Open Spaces such as urban green Spaces, squares and public sports fields within walking distance. ( )
17. Set up a centralized outdoor fitness activity area. ( )
18. Real-time information on water use available online. ( )
19. Conditions for standing water outside during rainy weather. ( )
20. Comfort of greenery around this building. ( )
21. Reasonable setting of outdoor smoking areas. ( )
22. The noise level of the outdoor site. ( )
23. Outdoor light pollution levels. ( )
24. Comfort with natural ventilation outside. ( )

25. Outdoor shade comfort. ( )

Public building questionnaire

Dear Sir/Madam! In order to understand your actual needs, understand your actual experience, in order to provide you with better projects and services later, I hope you fill in the following questionnaire according to your real ideas, thank you for your cooperation! Satisfaction scores range from low to high on a scale of 1–5.

Your gender: Male female

Your age: Under 18 18–30 31–50 51+

1. Balconies, exterior Windows, windowsills, protective railings, etc., have strengthened anti-fall design to reduce the risk of falling objects hurting people. ( )
2. Put anti-slip measures on the ground or pavement outside. ( )
3. Human-vehicle diversion, outdoor lighting effects. ( )
4. Durability of equipment such as lighting, faucets, plumbing, etc. in public areas. ( )
5. Use durable steel, anticorrosive wood and other building materials. ( )
6. Indoor floor tiles have good wear resistance and low breakage rate. ( )
7. Indoor public Spaces are well ventilated and odor-free. ( )
8. Outdoor landscape water is clean and pollution-free. ( )
9. Domestic water is clean and pollution-free. ( )
10. Indoor sound insulation effects. ( )
11. Indoor and basement lighting. ( )
12. Natural ventilation comfort in the building during the transition season. ( )
13. Accessibility to public transportation. ( )
14. The indoor and outdoor activity areas of the building meet the requirements of all-age design. ( )
15. The building has shared meeting facilities, fitness facilities, dining facilities, etc. ( )
16. Open Spaces such as urban green Spaces, squares and public sports fields within walking distance. ( )
17. Set up outdoor walking slow lanes. ( )
18. Mobile data network connection effect. ( )
19. Conditions for standing water outside during rainy weather. ( )
20. Comfort of greenery around this building. ( )
21. Reasonable setting of outdoor smoking areas. ( )
22. Noise levels in outdoor activity areas. ( )
23. Outdoor light pollution levels. ( )
24. Comfort in natural ventilation outside. ( )
25. Outdoor shade comfort. ( )

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