buildings

MDPI

Article

Exploring the Renovation Status and Flexible Strategies of Urban Housing in China Based on Two Surveys of Residents and Architects

Jie Huang [1,2], Jingmin Zhou [3], Song Gao [2] and Xiao Liu [4,5,6,7,*]

1 College of Architecture and Art, Hefei University of Technology, Hefei 230601, China
2 Anhui Architectural Design and Research Institute Co., Ltd., Hefei 230091, China
3 College of Architecture and Urban Planning, Tongji University, Shanghai 200092, China
4 State Key Laboratory of Subtropical Building Science, South China University of Technology, Guangzhou 510641, China
5 School of Architecture, South China University of Technology, Guangzhou 510641, China
6 Faculty of Architecture, The University of Hong Kong, Hong Kong, China
7 Architectural Design & Research Institute Co., Ltd., South China University of Technology, Guangzhou 510641, China
* Correspondence: xiaoliu@scut.edu.cn

Abstract: Housing renovations have become an important part of the construction of living environments in China, and improving residential flexibility is an important way to facilitate renovations. This study focused on the adjustments of interior space and living function from the perspective of the application of flexible design strategies through two-stage surveys. The renovation contents and needs of 439 residents were statistically analyzed, an evaluation of design strategies was performed by 226 architects, and a correlation analysis was carried out based on the data. The results showed that the distribution of renovations was positively related to the renovation difficulty and could be summarized into four parts, viz., functional arrangement, device and pipeline, furniture and storage, and decorative details, while the willingness to renovate was related to living requirements. Twenty design strategies for improving housing flexibility were evaluated, and a statistical analysis was carried out on the flexibility assessment and adoption willingness provided by architects. In 14 of these strategies, the flexibility assessment affected the architects' willingness to adopt the design ($p < 0.05$); however, the adoption willingness was affected by external factors in the other six strategies, such as cost control. In addition, the architects' adoption willingness score was generally lower than their assessment score for the same strategy; thus, top-level guidance to promote the application of flexible strategies should be strengthened.

Keywords: housing renovation; housing flexibility; renewal content; design strategy; flexibility assessment; adoption willingness

Citation: Huang, J.; Zhou, J.; Gao, S.; Liu, X. Exploring the Renovation Status and Flexible Strategies of Urban Housing in China Based on Two Surveys of Residents and Architects. *Buildings* **2022**, *12*, 1764. https://doi.org/10.3390/buildings12101764

Academic Editor: Kheir Al-Kodmany

Received: 3 October 2022
Accepted: 18 October 2022
Published: 21 October 2022

1. Introduction

In China, in order to meet the ever-changing needs of the population and improve the quality of residential buildings, housing renovations and the improvement of living environments have been the focus of the construction industry. In August 2021, the Ministry of Housing and Urban-Rural Development issued a "Notice on Preventing Large-scale Demolition and Construction in the Implementation of Urban Renewal Actions" to strictly control large-scale demolitions and additional construction [1] and to promote the renovation of existing buildings. Starting from the vital interests of residents, housing renovation aims to improve the utilization efficiency of existing buildings. The government has also put forward systematic requirements for residential buildings, community spaces, supporting facilities, and management mechanisms [2] to improve the quality of life of residents.

In "Maslow's hierarchy of needs", living requirements include multi-level issues, such as physiology, safety, social interaction, respect, and self-realization [3]. Although the commercial housing market in China is diverse and characterized by high demand, the types and layouts of houses in Chinese communities are relatively simple, and it is difficult to meet individualized needs. From previous research on living conditions, these diverse needs mainly arise due to the following events: changes in family structure, changes in economic conditions, the application of new technologies and equipment, the adaptation of the elderly, and other individualized requirements [4]. The dynamic changes in residential demand will inevitably lead to building transformation or relocation [5]. In addition, China has become an aging society; the proportion of the population aged 65 and above was 14.2% of the total population in 2021; and it is estimated that the proportion will exceed 20% by 2040 [6]. China is promoting home-based and in-place care [7], and meeting the living requirements of the elderly through transformation will also play a significant role in caring for the aging society.

Because of changing requirements, improving housing flexibility can help to relieve this residential problem to some extent. In China, developers build and offer unified residential units according to the same standard, especially in terms of the layouts on different floors in one building. Given this situation, housing flexibility makes living diversity and adaptability possible and it is an important foundation to meet the dynamically changing needs of society. The main purpose of housing flexibility is to find an adaptive balance between family structure, economic conditions, lifestyle, technological innovation, and other factors [8,9]. Tatjana Schneider and Jeremy Till proposed that housing flexibility could be divided into the following two categories: "soft flexibility" and "hard flexibility" [10,11], where hard flexibility is led by architects and interior designers, which means it should be added before moving, and soft is dominated by residents' participation. Flexibility mainly considers the changes in the space, texture, and constituent elements of a building from the perspective of physical form [12]. It can be temporary or permanent, and its achievement generally requires related devices or components with flexible characteristics. The integration of flexible design strategies in the design stage can facilitate the flexible adjustment of living and effectively extend the life cycle of buildings [13,14].

Leupen distinguished three categories of changeability in principle—alterable, extendable, and polyvalent [15]—covering the changes in space forms and function organization and summed up the spatial organization mode of "polyvalent dwelling" into the following five types: chain, radial, radial with core, circle, and grid [16]. Robert Schmidt and Simon Austin proposed that the adaptability of architecture is an important factor to prolong the useful life of buildings and we should view buildings as unfinished and continually shifting in form and purpose [17].

With the development of social diversification, many countries have successively issued design guidelines or related documents to guide the flexible design of housing. In 1965, the institution of Stiching Architecten Research (SAR) in the Netherlands proposed an innovative design method called SAR 65, which divided residential design and construction into two parts, the support structure and the infill function, and residents were encouraged to customize their living environment [18,19]. In the 1970s, Kyoto University in Japan proposed a two-stage supply housing model [20], in which the structure stage was responsible for the building assets, while the interior stage involved meeting residents' needs for housing diversity. Then, Japan Housing Corporation proposed programs of the Century Housing System (1980) and the Kikou Skeleton Infill (1997) successively to facilitate residential flexibility and adaptability [21,22]. In 1987, the U.S. Department of Housing and Urban Development launched "Adaptable Housing: A Technical Manual for Implementing Adaptable Dwelling Unit Specifications", which introduced the design methods, cost control, and related products for achieving housing adaptability at that time, focusing on adaptive strategies for kitchens and bathrooms [23]. North Carolina State University put forward the design principles of universal adaptive housing, which could be used to improve the adaptability and prolong the useful life of buildings [24].

Subsequently, other countries, including Canada [25,26], the UK [27], China [28] and Australia [29], successively launched relevant documents to guide the adaptability, flexibility, and sustainability of housing. Table 1 presents information of typical and impactful projects in the mid-to-late 20th century in this field.

Table 1. Projects on housing flexibility and adaptability in selected countries.

Name of Project	Year	Country	Agent	Flexibility and Adaptability
Support-infill Housing	1965	The Netherlands	Stiching Architecten Research (SAR)	Divides residential design and construction into two parts, the support structure and the infill function, to encourage residents to participate in individualized design and renewal [18].
Two-stage Supply Housing	1970	Japan	Kyoto University	Divides housing construction into the following two stages: the structure stage, responsible for the building assets, and the interior stage, to meet residents' needs for housing diversity [20].
Century Housing System (CHS)	1980	Japan	Japan Housing Corporation	CHS specifies the expected service life of each component, determines the standard of connection interfaces, and aims to develop components with different lifespans and realize flexible updates [21].
Adaptable Housing	1987	United States	The U.S. Department of Housing and Urban Development	Explains the features and advantages of adaptive housing and puts forward corresponding strategies for adaptability, in combination with technical conditions [23].
Universal Housing	1988	United States	North Carolina State University	Proposes seven principles of universal design and it points out that universal design should maximize the use of space and environment [24].
Grow Home	1990	Canada	McGill University	Grow Home can adapt to diverse conditions and different ages by transformation, especially for low-income families [25].
Lifetime Homes (LTHS)	1990	United Kingdom	Habinteg Housing Association and the Joseph Rowntree Foundation	Lifetime Homes are designed by considering flexibility and adaptability to create a better living environment for everyone, from children to the elderly [27].
Adaptive Housing with Universal Infill	1992	China	Ministry of Science and Technology of China	Combines an open building system with national conditions in China and proposes an adaptive infill system with diverse housing components [28].
Flex Housing	1995	Canada	Canada Mortgage and Housing Corporation	Flex Housing can be used to achieve physical changes and adapt to the changing living requirements of different families [26].
Universal Housing in Australia	1997	Australia	Australian Network for Universal Housing Design	Refers to a general-purpose building that adapts to different ages, family structures, and self-care abilities and has flexibility over time [29].
Kikou Skeleton Infill (KSI)	1997	Japan	Japan Housing Corporation	Realizes the flexible adjustment of functions, pipelines, etc., through the separation of the structure and interior systems. With the support of KSI, the service life of housing can exceed 100 years [22].

The purpose of these projects was to create more adaptable, flexible housing and to prolong the life cycle of existing buildings from a top-level guidance perspective. However, residential renovation is generally a multi-dimensional and microscopic behavior that needs to be adjusted according to specific requirements of flexibility; the renovation goals and strategies should be set on the premise of systematically understanding the current situation and conditions. The needs of residents and the flexible strategies created by

designers have important significance in the design of housing [30] and current research and projects are relatively lacking in this field. Therefore, we hope to propose appropriate flexibility strategies in view of diverse residential needs and renovation goals in the study. This research was divided into two parts. The first part involved an investigation of the renovation status in different households and an analysis of residents' willingness to renovate and expectation of flexibility. The second part focused on the role of design strategy in improving housing flexibility based on the renovation status, during which related strategies were evaluated by architects from two aspects, the flexibility of strategies and the willingness to adopt in the design, to provide helpful references for housing design.

2. Methods

2.1. Stage One: Renovation Status and Willingness of Households

In order to explore the current situation and residents' needs for spontaneous renovation (personalized, not including the government-led general renewals), a status survey was carried out among households in typical Chinese urban housing (multifamily housing) to analyze residents' needs and the key points of residential flexibility design, so as to provide a research basis for the proposal of further design strategies. The survey was mainly carried out in the form of questionnaires, and the questions included the following three aspects: household and building information, housing renewal contents, and households' needs for flexibility. In the early stage, a small-scale pre-investigation was carried out for the optimization of the questionnaire, which received positive feedback. A total of 40 questions were included in the final survey, including 28 single-choice questions, 5 multiple-choice questions, and 7 fill-in-the-blank questions, and questions related to this article are presented in Table A1 in Appendix A.

To make questionnaire surveys representative, sufficient and valid samples must be collected. According to previous research, the minimum non-probability sample size can be calculated according to the following statistical random sampling formula [31,32]:

$$n = Z^2\sigma^2/d^2, \quad (1)$$

where n is the sample size; Z is the confidence interval value (1.96 at a 95% confidence level); d is the margin of sampling error (5% in this survey); and σ is the standard deviation (0.5). In our study, the calculated minimum random sample size was 384.

The survey started in the winter of 2019; during 3 months of implementation, a total of 500 questionnaires were distributed and 478 were returned. Only completed questionnaires were used, and a final number of 439 valid samples were selected, covering different regions, including East, South, North, Northwest, and Southwest China. Valid questionnaires accounted for 87.8% of the total questionnaires, and the sample size met the statistical requirement ($n \geq 384$).

First, the personal information of respondents was recorded, covering different family structures and age groups, and the distribution of the sample was relatively balanced in terms of years of residence. In addition to personal information, it was also necessary to consider the building characteristics of the residences and the basic renewal situation, e.g., adjustments or changes in space and functions. The questionnaire recorded the residential information of the valid samples to summarize the current housing renovation situation and flexibility requirements. Table 2 shows the characteristics of the respondents, while Table 3 shows the characteristics of the respondents' housing.

In addition to this basic information, the survey also focused on the current situation of residential renovation and the flexibility needs of residents. The renovation situation involved reasons for renovation, changes to the structure, changes to external walls, layout adjustments, usable area adjustments, room quantity adjustments, storage space, furniture arrangement, decoration details, etc. Residential demand mainly considered satisfaction with the existing residential layout and flexibility, as well as the expected flexibility of residential components in an ideal residence. We also recorded the residents' expectations for housing flexibility in terms of functional arrangement, pipelines and equipment, furniture

and storage, and decoration and details with a five-point Likert scale and quantified the differences in the flexibility needs of households for renewal to provide a reference for research on flexible design strategies.

Table 2. Characteristics of the respondents.

Characteristics		Number (%)
Sex	Male	206 (46.9%)
	Female	233 (53.1%)
Age	Under 18 years old	6 (1.4%)
	18 y–40 y	376 (85.7%)
	41 y–59 y	52 (11.9%)
	60 y and above	5 (1.1%)
Family population	1 person	26 (5.9%)
	2 people	83 (18.9%)
	3 people	144 (32.8%)
	4 people	83 (18.9%)
	5–7 people	103 (23.5%)
Years of residence	Less than 1 year	88 (20.0%)
	1–3 years	136 (31.0%)
	4–10 years	112 (25.5%)
	11–20 years	84 (19.1%)
	More than 20 years	19 (4.3%)

Table 3. Characteristics of the respondents' housing.

Characteristics		Number (%)
Area of layout	Less than 90 m^2	139 (31.7%)
	90–144 m^2	249 (56.7%)
	More than 144 m^2	51 (11.6%)
Year of construction	Before 1980	10 (2.3%)
	1980–2000	108 (24.6%)
	2001–2010	149 (33.9%)
	2010 to present	172 (39.2%)
Building height	Low	25 (5.7%)
	Multiple	140 (31.9%)
	Sub-high-rise	61 (13.9%)
	High-rise	213 (48.5%)
Times decorated after moving in	None	98 (22.3%)
	Once	284 (64.7%)
	Twice	46 (10.5%)
	More than twice	11 (2.5%)
Structure form *	Shearing wall	108 (24.6%)
	Brick	81 (18.5%)
	Concrete frame	78 (17.8%)
	Other structures	12 (2.7%)
	No answer	62 (14.1%)

* Total number was less than 439 because 98 respondents without decoration experience were not asked.

2.2. Stage Two: Design Strategies from Architects

After the survey of renovation status of urban housing in China, the flexibility requirements were collected and analyzed against this background, and some issues related to the renovation status could be resolved from the perspective of architectural design. In order to study how design strategies can help improve residential flexibility, existing strategies for different design contents were classified according to a survey of renovation status and existing outcomes and divided into two categories—designer-led and resident-led

strategies [33]. Resident-led strategies mainly focus on the retrofit content of furniture and decoration details, which is related to the selection of diverse interior products, such as folding tables and chairs. On the other hand, designer-led refers to the design strategies considered in architectural design, which provide housing with potential flexibility; these strategies were the focus of this research, which included an assessment of flexibility and adoption willingness by designers.

We previously summarized some strategies to improve housing flexibility [34,35]. This study considered a total of 20 flexible design strategies, mainly designer-led, before issuing questionnaires and carrying out interviews that covered general structure and external walls, functional arrangement, device and pipeline, furniture and storage, decoration and details, etc., which can help to improve potential flexibility in different fields, as shown in Table 4. Since these strategies were derived from a literature review and case studies, which we were unable to validate, we carried out an in-depth survey of architects, mainly focusing on the architects' assessment of flexibility and their willingness to adopt each strategy.

Table 4. Twenty design strategies related to housing flexibility.

No.	Name of Strategy	Explanation	Field of Flexibility
1	Wet and dry zoning	The potential water-use space and non-water-use space are divided in the layout to facilitate the reorganization of functions.	Functional arrangement
2	Sectional descending board	The structural floor of the bathroom is lower than in other places, creating a certain height difference for the arrangement of pipelines.	Structure and external wall
3	Same-floor drainage	Drainage and sewage pipes do not pass through the structural floor, and horizontal pipelines can be arranged on the floors to connect the main vertical pipes.	Structure, device and pipeline
4	Unit bathroom	Sanitary ware, finishes, pipelines, and waterproof layers required for the bathroom are integrated inside the unit box.	Device and pipeline
5	Integrated kitchen	Cooking facilities, sanitary ware, pipelines, and finishes are integrated as a whole product, which is easy to disassemble and adjust.	Device and pipeline
6	Horizontal exhaust	The flue gas is directly discharged to the exhaust port on the facade through horizontal pipes, without the need for a public flue well.	Device and pipeline
7	External tube well	Traditional indoor tube wells (water, flue) are centrally arranged outside the layout, usually in public areas or outdoors.	Structure and external wall
8	Horizontal structural component optimization	Horizontal structure beams or walls are arranged as far apart as possible on the exterior wall and the household-separating wall to reduce the impact on the spatial form.	Structure and external wall, functional arrangement
9	Vertical structural component optimization	Vertical structure columns or shear walls are arranged as far apart as possible on the exterior wall and the household-separating wall to reduce the impact on the spatial form.	Structure and external wall, functional arrangement
10	Modular coordination	Components and parts with a standardized modulus are selected in the design, along with a suitable modulus grid to facilitate the ease of construction and assembly.	Functional arrangement, furniture and storage
11	Universal space	Rooms are designed according to the unified standard, and each specific function is determined by the resident.	Functional arrangement

Table 4. *Cont.*

No.	Name of Strategy	Explanation	Field of Flexibility
12	Raised flooring system	The indoor floor is separated from the slab with anchor bolts and the floor heating and other pipelines can be arranged in the overhead layer, which can facilitate adjustment and maintenance.	Device and pipeline
13	Light partition wall	A finished light wall panel or keel partition wall system is chosen to realize space division and decoration, which can facilitate disassembly or adjustment.	Functional arrangement, device and pipeline
14	Movable partition wall	Foldable or movable wall systems are chosen to realize the division of space and functions, which is convenient for space adjustment.	Functional arrangement, device and pipeline
15	Equipment assistance	Mechanical equipment is set up in the floors and walls, which can help to realize transformation by adjusting the space's form and size using an intelligent system.	Device and pipeline
16	Pipeline separation	Pipelines are arranged in the overhead layer of raised floors, suspended ceiling or prefabricated walls, which will not damage the structure and can facilitate renovation.	Device and pipeline
17	Space-saving cables and components	The use of small diameter or flat cables is directly combined with the decorative surface, which can save space and reduce the need for covering treatment for these cables.	Device and pipeline
18	Order control	The order of construction is determined according to the usage life of components, where the short-lived components are easier to disassemble.	Functional arrangement, device and pipeline
19	Detachable construction	The decorative layer and other components of the wall are connected to the keel or the structure through a detachable interface.	Device and pipeline, decoration and details
20	Foldable furniture	The form of the furniture can be changed by folding, moving, deformation, etc., to adapt to different functional needs.	Functional arrangement, furniture and storage

From November to December 2019, these 20 strategies were combined into a survey questionnaire, and pre-investigation and optimization were carried out in a small group. From January to May 2020, the questionnaire was officially issued and answered. In order to ensure the credibility and validity of the collected data, the questionnaire included two parts, personal information and strategy evaluation, which can be found in Table A2 in Appendix B. It required respondents to provide a real name and required designers to provide personal information, such as their email, working years, experience related to housing design, etc., for further consultation.

A total of 240 questionnaires were distributed in East, North, Central, South, and Western China to mainstream design institutes, such as the Tongji Architectural Design Group, China Institute of Building Standard Design and Research, China Northwest Architectural Design and Research Institute, Architectural Design and Research Institute of SCUT, etc., as well as companies that were known for residential design, such as UA Design, Lacime Architects, TIANHUA Architectural Design, GAD Design, Ji Zhun Fang Zhong Architectural Design, etc. A total of 226 valid samples were collected, with an effective rate of 94.2%. The respondents' working years, experience in residential projects, experience in interior design, experience in housing flexibility design, and other aspects were obviously different; thus, their answers were representative. Some characteristics of the respondents are shown in Table 5.

Table 5. Characteristics of architect respondents.

Characteristics		Number (%)
Working years	1–3 years	88 (38.9%)
	4–9 years	99 (43.8%)
	10 years and more	39 (17.3%)
Number of housing projects involved in	None	29 (12.8%)
	1–4	96 (42.5%)
	5–9	46 (20.4%)
	10 and more	55 (24.3%)
Experience in interior design	Yes	90 (39.8%)
	No	136 (60.2%)
Experience in flexibility design *	Yes	153 (75.7%)
	No	49 (24.3%)

* The respondents with experience in flexibility design were selected as those with experience in housing design and interior design.

The evaluation of the 20 strategies included an assessment of flexibility and the respondents' willingness for adoption. The architects scored each strategy one by one using a seven-point Likert scale, i.e., a minimum of one point and a maximum of seven points, where the value is an integer. A total of 226 groups of valid data were collected and tested, and the reliability and validity of the data met the requirements of the study (Cronbach's alpha >0.85). The specific analysis was divided into the following three parts: (1) using mean statistics, we quantitatively analyzed the architects' flexibility assessment and adoption willingness of the 20 strategies, and described the differences between strategies. (2) Using correlation analysis between flexibility assessment and adoption willingness, we screened out strategies with significant differences (p value < 0.05) and further analyzed the reasons for some typical strategies having different p values. (3) Combining correlation analysis and median statistics, we analyzed the logical relationship of strategy selection and discussed the application of different strategies with suggestions.

3. Results and Discussion

3.1. Renovation Status and Flexibility Expectations

In the survey of renovation status and flexibility expectations, a total of 439 valid respondents answered the questionnaire. There were 284 samples where only 1 experience with renovation was reported, and 47.2% of these had decorated before moving in. This was followed by second-hand house renovations, accounting for 22.5%, while the remaining purposes were decoration after renting, structural reinforcement, circuit retrofit, etc. There were 57 respondents who reported experience with 2 or more renovations, and more than half of these reported that the latest renovation was carried out to improve their living environment after an improvement in economic conditions; in addition, the average time between two renovations was 5.8 years, which is relatively short. There were 98 respondents that reported having no renovation experience; these individuals were only asked about their satisfaction with and expectations of housing decoration and flexibility.

3.1.1. Renovation Contents

A total of 341 respondents reported having experience in interior decoration or renovation. We collected information on different aspects of the specific renovation contents, including building structure, exterior wall, layout, area, number of rooms, furniture, etc.

Structural components are closely related to residential safety, and their adjustment or demolition can result in hidden dangers. However, there are some renovations of hidden pipelines that involve the opening and slotting of the building structure. Most respondents to the survey reported that they did not adjust structural systems, 13.2% made some small changes to the structure, and the rest did not know whether there were any adjustments made during the renovation, as shown in Figure 1a.

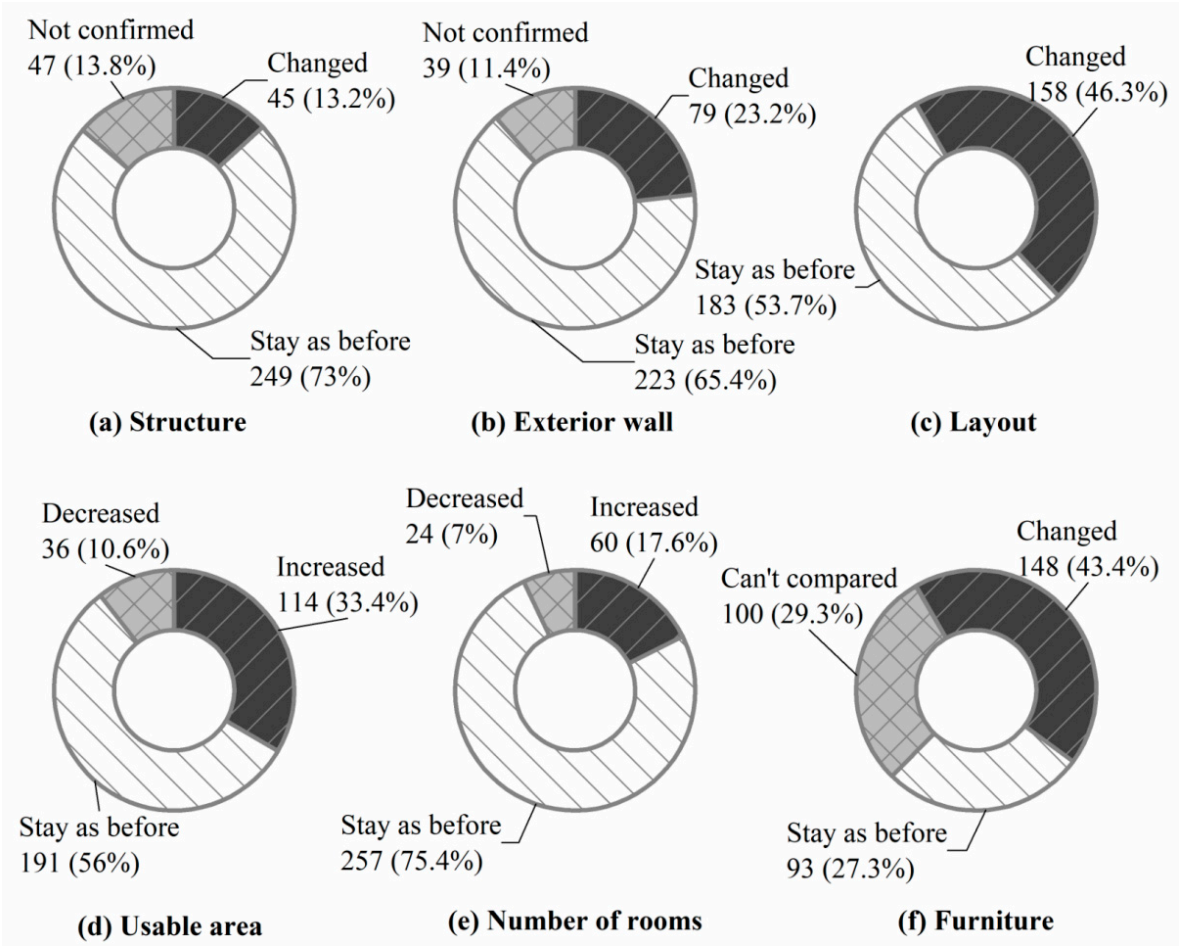

Figure 1. Distribution of the renovation status of different contents.

The exterior wall plays a role in the physical performance of buildings, and its adjustment may affect the performance of waterproofing and thermal insulation. In this questionnaire, 23.2% respondents reported making some changes to exterior walls, while 65.4% had no retrofit because they were unable to change their building facade or for other reasons (proportion shown in Figure 1b).

Due to the requirements of building regulations and codes in China, the adjustment of indoor function and space by the residents themselves generally cannot affect the architectural form and physical performance. In the field investigation, we found that changes that affect architectural performance and form were also not allowed by the department of property management. In terms of functional layout, nearly half of the respondents (46.3%) had made some changes (see Figure 1c) that involved multiple functions. Among these, the living room was the most frequent location for changes, accounting for 53.2%, followed by the bedroom (44.9%), while the proportions of changes to the balcony, kitchen, and dining room were almost the same (about 38%); most chose to maintain the original bathroom layout.

In terms of indoor usable area, adjustments can be made by connecting balconies, enclosing patios, and removing separation walls. More than half of the households surveyed did not make any adjustments; however, 33.4% of them increased their usable area through renovation, while 10.6% of them reduced their usable area (see Figure 1d). The changes were mainly carried out in the living room (78%), followed by the balcony, bedroom, kitchen, dining room, bathroom, and other.

In terms of room quantity, 75.4% of households did not make any changes, which was mainly due to the structural layout. Some housing structural systems limit the possibility of adjusting the number of rooms, especially shear-wall and brick/concrete structures. The

remaining 84 samples (24.6%) reported making adjustments to varying degrees, as shown in Figure 1e.

In terms of furniture, 43.4% of households changed their furniture arrangements or updated furniture products during renovation, while 27.3% continued to use their original furniture. Since this statistic included respondents who reported decorating before moving in, some adjustments could not be compared with the initial state.

From the statistical analysis of the contents of respondents' renovations, the proportion of individuals who made adjustments to the indoor layout, area size, number of rooms, furniture arrangement, etc., was relatively high, while the proportion who made adjustments to the structure and exterior wall was lower, which was positively related to the difficulty of renovation.

3.1.2. Satisfaction and Expectation

In addition to their renovation situation, this questionnaire also assessed residents' satisfaction with and needs for housing flexibility; the total number of valid samples was 439 in total.

Figure 2 shows the distribution of respondents' satisfaction with the current status of their housing and its potential for flexibility. Of these, 58.8% were satisfied or very satisfied with their housing layout and decoration, 4.1% were dissatisfied or very dissatisfied with their home, and the rest were neutral. In terms of potential flexibility, 54.2% were satisfied or very satisfied with the current flexibility of their housing, 11.4% were not satisfied or very dissatisfied, and the rest were neutral. It can be observed from the statistics that more than half of the families surveyed were generally satisfied with their living environment, while the remaining might consider how to improve their living environment.

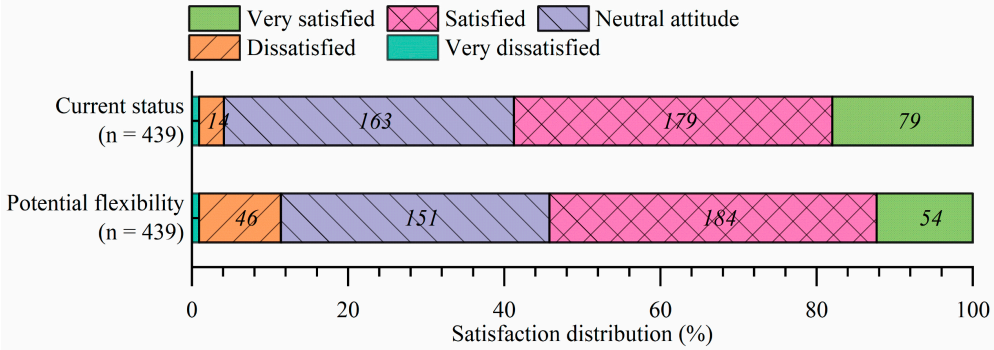

Figure 2. Satisfaction on the current status and potential flexibility of housing.

In order to further understand the specific needs of residents for housing renewal, we also conducted research on their expectations for flexibility in specific renovation components, including the following four areas: functional arrangement, device and pipeline, furniture and storage, and decoration and details (see Figure 3). Through statistical analysis, we found that the flexibility requirements of these contents were relatively high. For all four areas, 26.8% of respondents answered "very desirable", 50.1% "desirable", 4.7% "undesirable", and less than 1% "very undesirable". The distribution of residents' expectations for each sub-item is represented in Figure 3. The demand for flexibility in functional layout was the lowest compared to the other three areas, while the demand for flexibility in interior finishes was the highest. The main reason for this is that the flexibility of furniture and decorative details is more closely related to the living feel of households and is easier to realize, while the adjustment of function and pipelines is more difficult for households to carry out. In addition, 20 items that belonged to the 4 areas were collected during the pre-research stage, including balcony forms, sockets and switches, storage spaces, etc. The respondents were allowed to choose multiple options for these items in their ideal residence. We collected data on the residents' perception of the importance of each item and sorted them by frequency, as shown in Figure 4. The highest importance

was assigned to "function redefinition", chosen by a total of 192 respondents, followed by "room size adjustment" and "balcony form", while the least flexibility demand was reported for the "exhaust duct line", which only 57 respondents thought was important. From this result, it could be found that the flexibility requirements of the residents for the ideal house and the current house were not completely consistent, and the ideal home should have priority in the flexibility of functional arrangement, in comparison with the flexibility of interior finishes.

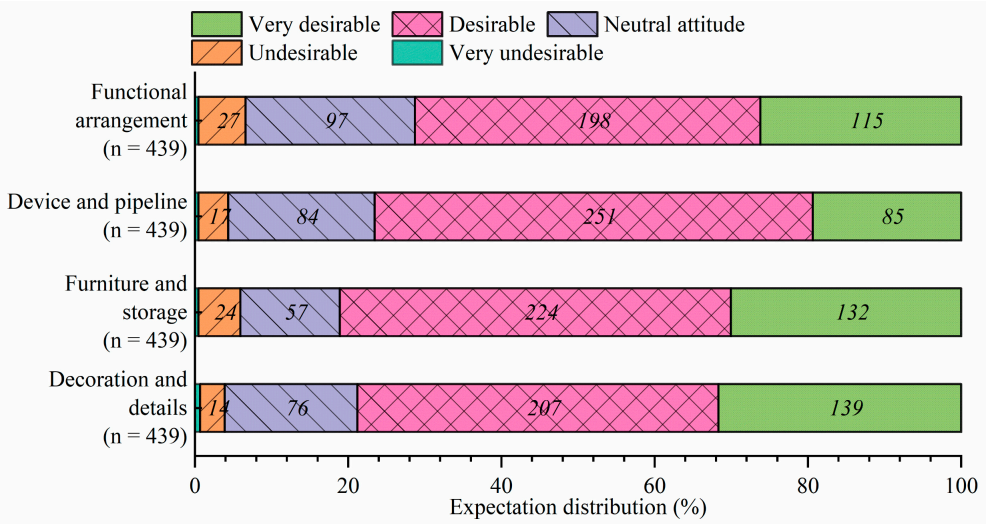

Figure 3. Expectations for flexibility in four areas of housing design.

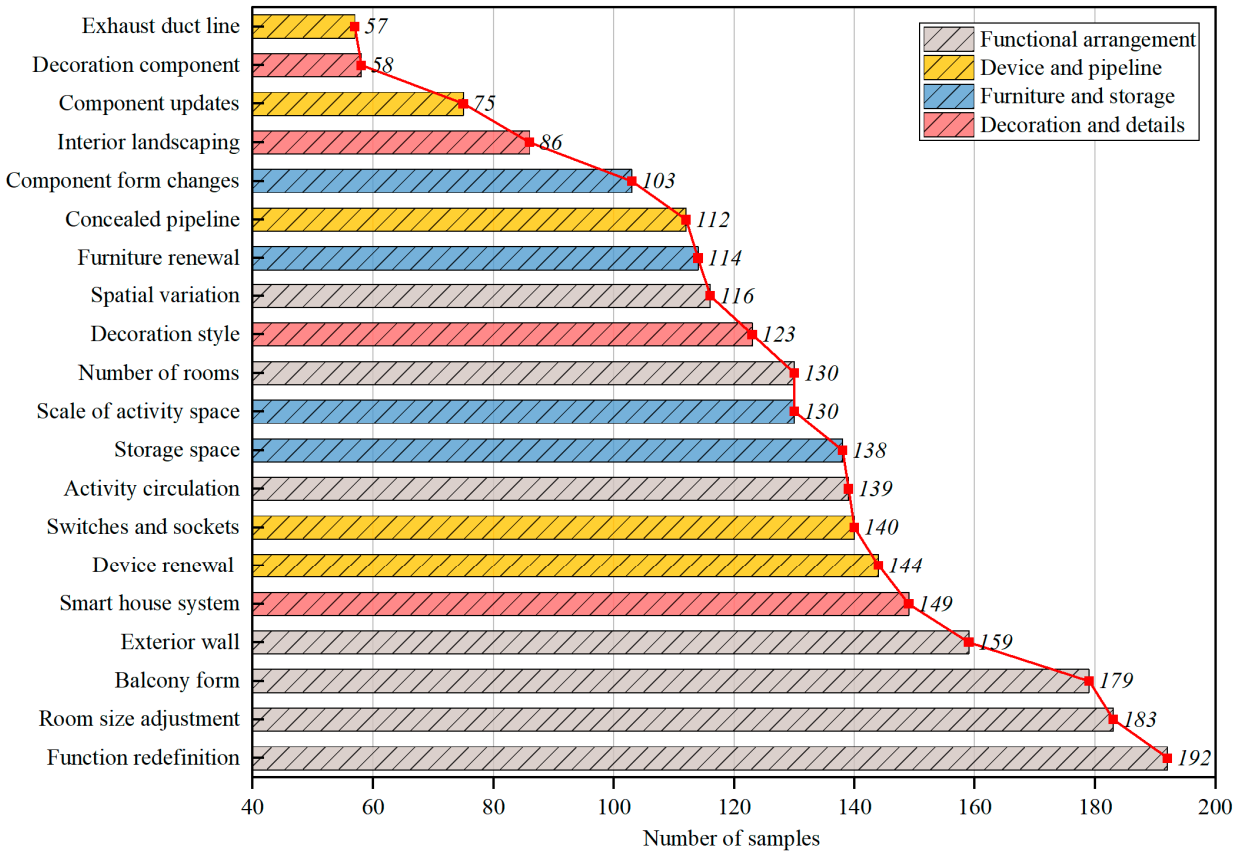

Figure 4. Expectations of the flexibility of specific components.

3.2. Evaluation of Design Strategies

In view of the information gathered on renovation status and flexibility expectations, we summarized 20 design strategies to improve residential flexibility and conducted an evaluation survey among architects, with 226 valid samples. The evaluation was quantified with a seven-point Likert scale, in which the minimum score for each strategy was one point and the highest was seven points. First, mean statistics were calculated for the flexibility assessment and adoption willingness of each strategy, and the 20 strategies were compared to elucidate the differences between them. Second, the correlation and significant difference between the two dependent variables—adoption willingness (*AW*) and flexibility assessment (*FA*)—were calculated using a "paired samples T test" and the data from 226 architects' evaluations. The statistical results are shown in Table 6.

Table 6. Statistics for the evaluation of each strategy.

No.	Name of Strategy	Variable	Mean	Standard Deviation	S.E. Mean	Correlation	Sig. (Two-Tailed)
1	Wet and dry zoning (WDZ)	*AW* *FA*	5.367 5.266	1.609 1.503	0.107 0.100	0.594	0.278
2	Sectional descending board (SDB)	*AW* *FA*	5.089 4.434	1.726 1.970	0.115 0.131	0.633	0.000
3	Same-floor drainage (SFD)	*AW* *FA*	4.673 4.735	1.883 1.918	0.125 0.128	0.625	0.572
4	Unit bathroom (UB)	*AW* *FA*	4.677 4.929	1.878 1.824	0.125 0.121	0.693	0.010
5	Integrated kitchen (IK)	*AW* *FA*	4.757 4.974	1.781 1.754	0.118 0.117	0.712	0.016
6	Horizontal exhaust (HE)	*AW* *FA*	3.704 4.022	2.001 2.005	0.133 0.133	0.716	0.002
7	External tube well (ETW)	*AW* *FA*	4.500 4.801	1.794 1.741	0.119 0.116	0.735	0.001
8	Horizontal structural component optimization (HSCO)	*AW* *FA*	5.580 5.509	1.495 1.558	0.099 0.104	0.680	0.385
9	Vertical structural component optimization (VSCO)	*AW* *FA*	5.739 5.850	1.385 1.355	0.092 0.090	0.671	0.136
10	Modular coordination (MC)	*AW* *FA*	5.602 5.549	1.389 1.563	0.092 0.104	0.707	0.485
11	Universal space (US)	*AW* *FA*	4.341 4.389	1.795 1.806	0.119 0.120	0.779	0.542
12	Raised flooring system (RFS)	*AW* *FA*	4.288 4.540	1.734 1.739	0.115 0.116	0.600	0.015
13	Light partition wall (LPW)	*AW* *FA*	5.212 5.615	1.702 1.499	0.113 0.100	0.736	0.000
14	Movable partition wall (MPW)	*AW* *FA*	4.704 5.345	1.730 1.593	0.115 0.106	0.631	0.000
15	Equipment assistance (EA)	*AW* *FA*	4.106 4.757	1.801 1.786	0.120 0.119	0.591	0.000
16	Pipeline separation (PS)	*AW* *FA*	4.589 4.925	1.719 1.694	0.114 0.113	0.632	0.001
17	Space-saving cables and components (SSCC)	*AW* *FA*	4.903 5.283	1.600 1.535	0.106 0.103	0.694	0.000
18	Order control (OC)	*AW* *FA*	4.544 4.903	1.736 1.654	0.115 0.110	0.692	0.000
19	Detachable construction (DC)	*AW* *FA*	4.867 5.297	1.592 1.438	0.106 0.096	0.664	0.000
20	Foldable furniture (FF)	*AW* *FA*	4.956 5.425	1.728 1.696	0.115 0.113	0.735	0.000

The mean values of the flexibility assessment scores for these 20 strategies were all above 4, which means that these strategies are capable of proving the flexibility of housing design. Most mean values of the adoption willingness scores were above 4, except strategy HE, which means that architects are generally willing to apply them in the design. The overall average score for adoption willingness was 4.81, and the score for overall flexibility assessment was 5.03, i.e., the willingness of the architects to use these strategies was less than their assessment of the strategies' flexibility. Among the strategies, that with the highest score in the flexibility assessment was "vertical structural component optimization", with an average score of 5.850; in addition, the architects were also the most willing to adopt this strategy, with an average score of 5.739. The strategy with the lowest flexibility assessment score was "horizontal exhaust", with an average score of 4.022; this strategy also had the lowest value for adoption willingness, with an average score of 3.704. The mean values for the flexibility assessment and adoption willingness of the other strategies were between the two described above, as shown in Figure 5.

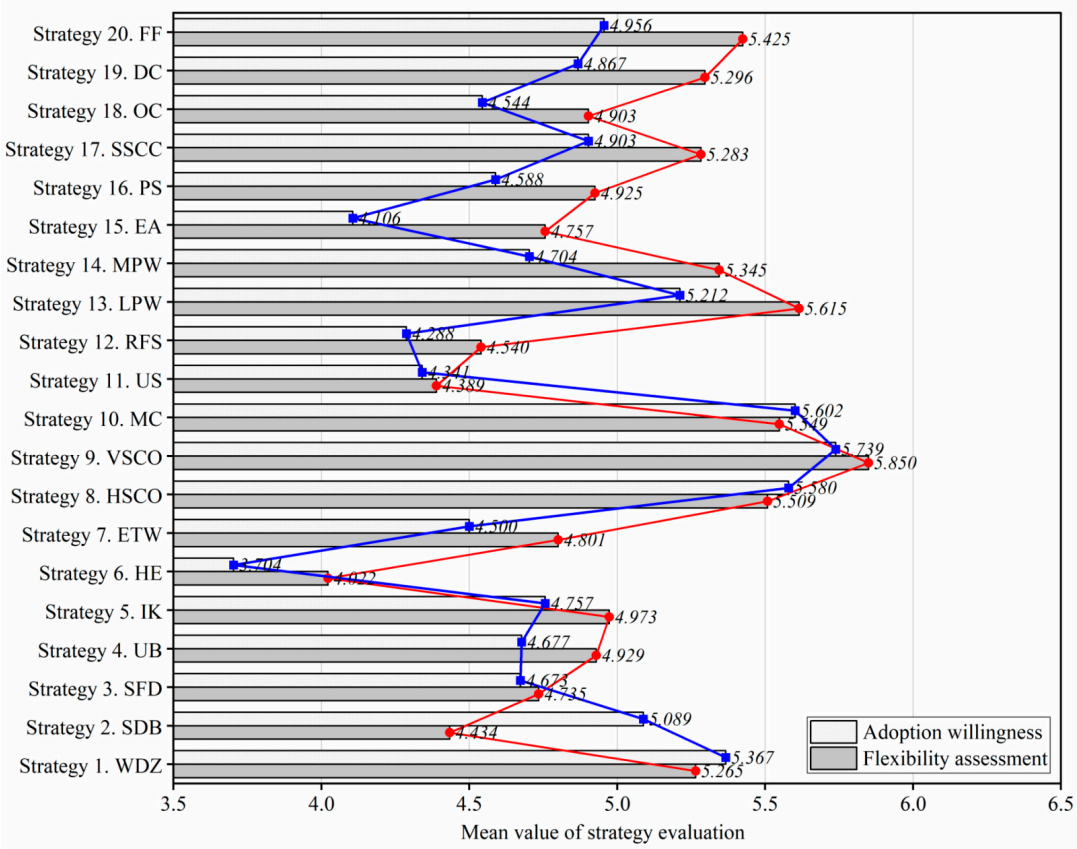

Figure 5. Mean statistics for flexibility assessment and adoption willingness.

In order to reveal the correlation between the flexibility assessment and adoption willingness, and to understand the differences in the characteristics of each strategy, paired sample tests were conducted for all 20 strategies. The Pearson correlation coefficient (r value) for the flexibility assessment and adoption willingness of each strategy ranged from 0.591 to 0.779, which indicated that these two aspects were positively correlated ($r > 0$). To further study the significant differences (p-value) between these two aspects, the flexibility assessment and adoption willingness variables were treated as paired contrasting dependent variables, and 226 datapoints were calculated for each strategy (two-tailed test). From the results of the T-test, as shown in Table 6, 14 strategies (No. 2, 4, 5, 6, 7, 12, 13, 14, 15, 16, 17, 18, 19, and 20) showed significant differences ($p < 0.05$): some exhibited extremely significant differences ($p < 0.001$), while the difference between the other 6 strategies (No. 1, 3, 8, 9, 10, and 11) was not significant ($p > 0.05$).

In the questionnaire for architects (see Table A2 in Appendix B), the scoring of flexibility assessment and adoption willingness was required for each strategy, and architects would comprehensively analyze their flexible features and decide whether to use these strategies in the housing design. The analysis of significant difference indicated that the flexibility assessment of most strategies affected whether the designer was willing to adopt it in their designs, especially for strategies with extremely significant differences, while the relationship between these two aspects for the other six strategies, including WDZ, SFD, HSCO, VSCO, MC and US, was relatively weak. This suggests that adoption willingness is mainly affected by other factors, such as the requirements of developers, the application of new technology, etc. We also conducted some interviews with architects, which also verified the indication results of significant difference.

Figure 6 shows the distribution of scores from 226 architects on the 2 aspects of the 20 strategies considered. For strategies 1, 3, 8, 9, 10, and 11 with no obvious significant differences, the distributions of the flexibility and adoption scores were basically the same; however, there still were some differences observed. In terms of these six strategies, although adoption intention was not directly affected by the flexibility assessment, strategies with higher scores (median or mean), including strategies 8, 9, and 10, could be prioritized in the design. For other strategies with significant differences, the distribution of the adoption scores was generally lower than that of the flexibility scores, except for strategy 2; this is reflected in the mean statistics in Figure 5. These strategies should be strengthened in housing design and construction with top-level guidance. For example, the strategy "pipeline separation" has an obvious effect on improving functional flexibility and decreasing the difficulty of renovation in practice; however, the motivation and willingness of designers are insufficient, considering the extra cost and design difficulties. Thus, guidance via policies and norms is required to assist in the improvement of housing flexibility.

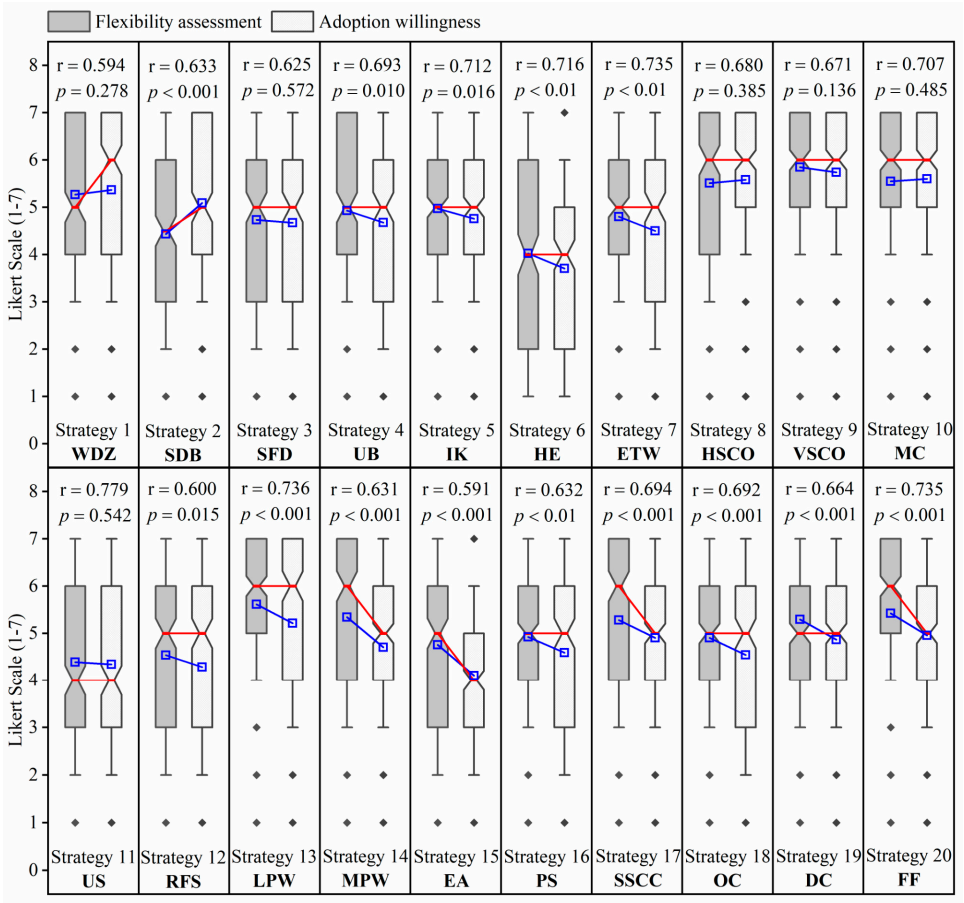

Figure 6. Distribution scores of 2 aspects of the 20 strategies (The red line indicates the median value and the blue line indicates the mean value).

In summary, it can be observed that the 20 design strategies for improving housing flexibility considered here have potential. In this study, designers recognized and confirmed the potential flexibility of these strategies; however, their willingness to adopt them was found to be affected by flexibility assessment and external factors to varying degrees, such as cost control, developers' requirements, government macro control, etc. When improving the flexibility of housing in the design stage, we must pay attention to the application of relative design strategies, give priority to those strategies with high flexibility evaluations, and reduce the adverse effects of external factors under the premise of improving comprehensive benefits to give full play to the value of early design in the improvement of housing flexibility.

4. Limitation

This study has some limitations, which are as follows:

(1) Housing renovation is a comprehensive issue [36] that includes physical form, economic cost, living needs, etc., and design can only help solve a small number of these problems and is not a main factor. Moreover, housing flexibility is not only a matter of design; a number of other aspects are also significant, such as selection of materials, facility assistance, and household participation. This study mainly focused on renovation and flexibility from the designer's perspective and did address other equally important fields.

(2) The application of flexibility design strategy needs to consider the acceptance of developers, residents, and other groups, rather than the wishful thinking of designers. This research on design strategies was mainly aimed at the design problem itself, rather than systematically solving housing flexibility. This research should be further extended to the study of flexibility mechanisms in other disciplines, e.g., the role of external influences in the adoption willingness of strategies could be quantified.

(3) This research was aimed at urban multifamily housing in China, which is characterized by mainly multi-story or high-rise residential buildings, and did not cover all residential types; thus, the status and solutions only represent part of housing in China. In addition, the sample size of survey was relatively limited, and regional and architectural differences were not reflected in the statistics; especially, the in-depth research and comparison analysis for specific building types was lacking in this study [37–41].

5. Conclusions

Residential flexibility has always been an important issue in housing design, and the significance of improving flexibility is mainly reflected in the renovation stage. This study analyzed the current situation of housing renovation in China and conducted further research on the design strategies available to improve flexibility from the perspective of architects. The main conclusions can be summarized as follows:

(1) In housing renovation, the contents for different families were diverse. The proportion of residents who made adjustments or changes in the six main areas (structure, exterior wall, layout, area, room number, and furniture) was different and was related to the renovation difficulty, e.g., the proportion of structure adjustment was lower than furniture changes.

(2) Residents' demand for renovations generally comes from changes in living requirements. An analysis of the demand for flexibility in four areas was conducted, for which the degrees of demand from high to low were as follows: decoration and details, furniture and storage, device and pipeline, and functional arrangement. In addition, a survey on the flexibility expectations of 20 items of the ideal house showed that flexibility in "function redefinition" was the most welcomed, and the flexibility of functional arrangement took priority over indoor finishes.

(3) Twenty design strategies to improve housing flexibility were summarized, and we carried out a statistical analysis of the flexibility assessment and adoption willingness

of each strategy provided by 226 architects. All these strategies were shown to be helpful in improving residential flexibility and adaptability to a certain extent (mean value of flexibility assessment was more than 4), and the architects' willingness to adopt each strategy was generally lower than their assessment of its flexibility.

(4) The flexibility assessment and adoption willingness of strategies were correlated. Fourteen strategies showed significant differences between these two variables ($p < 0.05$), where flexibility assessment of the design strategies affected the adoption intention, whereas the other six strategies did not show significant differences between these two aspects. From the perspective of strategy application, top-level guidance should be strengthened to reduce the adverse impact of other factors, and those strategies with high flexibility evaluations should be preferred.

This study only discussed the issue of housing design facilitating flexible renovation; however, building renovations have always been a multidisciplinary and comprehensive problem. We hope that this study can provide some guidance for future in-depth research from other perspectives.

Author Contributions: Conceptualization, J.H. and J.Z.; methodology, J.H. and X.L.; software, J.H.; validation, J.H. and J.Z.; investigation, J.H., X.L. and S.G.; data curation, J.H.; writing—original draft preparation, J.H. and X.L.; writing—review and editing, J.H. and X.L.; supervision, J.Z. and S.G.; funding acquisition, X.L. and J.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research is supported by the Anhui Provincial Natural Science Foundation (grant no. 2108085QE240); the National Natural Science Foundation of China (grant no. 52108011); the Fundamental Research Funds for the Central Universities (grant nos. JZ2021HGQA0223, PA2021KCPY0038 and QNMS202211); Guangzhou Philosophy and Social Science Planning 2022 Annual Project (grant no. 2022GZQN14); State Key Laboratory of Subtropical Building Science, South China University of Technology (grant no. 2021ZB16); Department of Housing and Urban–Rural Development of Guangdong Province (grant no. 2021-K2-305243); Department of Education of Guangdong Province (grant no. 2021KTSCX004); Science and Technology Program of Guangzhou, China (grant no. 202102020302); China Postdoctoral Science Foundation (grant no. 2021M701249).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are available within the article.

Acknowledgments: The authors are very grateful to the architects and residents who were interviewed and filled out the questionnaires. This research also was supported by Hefei Human Resources and Social Security Bureau.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The questionnaire for residents *.

Household and Building Information	
1. Please choose your gender. (Single choice)	(1) Male; (2) Female
2. What is your age? (Single choice)	(1) Under 18 years old; (2) 18–40 years old; (3) 41–59 years old; (4) 60 years old and above
3. What is the type of residence? (Single choice)	(1) Family owned; (2) Rented housing; (3) Others (Fill in the blank)
4. Where is the residence located? (Fill in the blank)	
5. What is the area of the layout of your house? (Single choice)	(1) Less than 90 m^2; (2) 90–144 m^2; (3) More than 144 m^2

Table A1. *Cont.*

Household and Building Information	
6. What is the housing type in height? (Single choice)	(1) Low (less than 3 stories); (2) Multiple (4–6F); (3) Sub-high-rise (7–9F); (4) High-rise (10F and above)
7. What is the construction age of the property? (Fill in the blank)	
8. How long have you lived in the house? (Single choice)	(1) Less than 1 year; (2) 1–3 years; (3) 4–10 years; (4) 11–20 years; (5) More than 20 years
9. What is the number of resident members of family? (Fill in the blank)	
10. How many times have you (or other members in your family) decorated the home? (Single choice)	(1) None; (2) Once; (3) Twice; (4) More than twice
11. What is the main purpose for the last decoration? (Fill in the blank)	
12. How many years have passed between the last renovation and the previous renovation? (Fill in the blank)	
13. What is the structure form of the building? (Single choice)	(1) Shearing wall; (2) Brick; (3) Concrete frame; (4) Other structures; (5) I do not know
Housing Renewal Contents	
14. During the decoration and renovation, have you made any adjustments to the structure? (Single choice)	(1) Changed; (2) Same as before; (3) Not confirmed
15. During the decoration and renovation, have you made any adjustments to the exterior wall? (Single choice)	(1) Changed; (2) Same as before; (3) Not confirmed
16. During the decoration and renovation, have you changed the layout of space and functions? (Single choice)	(1) Changed; (2) Same as before
17. If there are any changes to the layout, where are they? (Multiple choices)	(1) Bedroom; (2) Living room; (3) Dining room; (4) Bathroom; (5) Kitchen; (6) Balcony; (7) Others (Fill in the blank)
18. During the decoration and renovation, have you adjusted the indoor usable area? (Single choice)	(1) Increased; (2) Decreased; (3) Same as before
19. If there are any changes to the usable area, where are they? (Multiple choices)	(1) Bedroom; (2) Living room; (3) Dining room; (4) Bathroom; (5) Kitchen; (6) Balcony; (7) Others (Fill in the blank)
20. During the decoration and renovation, have you adjusted the quantity of rooms? (Single choice)	(1) Increased; (2) Decreased; (3) Same as before
21. If there are any changes to the number of rooms, please tell us if the specific function increased or decreased. (Fill in the blank)	
22. During the decoration and renovation, have you changed the arrangement and type of furniture? (Single choice)	(1) Changed; (2) Same as before; (3) Cannot compare
Households' Need for Flexibility	
23. How do you like the current status of your housing? (Single choice)	(1) Very satisfied; (2) Satisfied; (3) Neutral; (4) Dissatisfied; (5) Very dissatisfied
24. How do you like the potential flexibility of your housing? (Single choice)	(1) Very satisfied; (2) Satisfied; (3) Neutral; (4) Dissatisfied; (5) Very dissatisfied
25. What are your expectations for the flexibility in functional arrangement following housing renovation? (Single choice)	(1) Very desirable; (2) Desirable; (3) Neutral; (4) Undesirable; (5) Very undesirable
26. What are your expectations for the flexibility in devices and pipelines following housing renovation? (Single choice)	(1) Very desirable; (2) Desirable; (3) Neutral; (4) Undesirable; (5) Very undesirable
27. What are your expectations for the flexibility in furniture and storage following housing renovation? (Single choice)	(1) Very desirable; (2) Desirable; (3) Neutral; (4) Undesirable; (5) Very undesirable

Table A1. *Cont.*

Household and Building Information	
28. What are your expectations for the flexibility in decorative details following housing renovation? (Single choice)	(1) Very desirable; (2) Desirable; (3) Neutral; (4) Undesirable; (5) Very undesirable
29. If you had the chance to design an ideal house, which of the following components do you think are more important in flexibility? You have 10 possible choices. (Multiple choices)	(A1) Exterior wall; (A2) Balcony form; (A3) Number of rooms; (A4) Spatial variation; (A5) Room size; (A6) Function redefinition; (A7) Activity circulation; (B1) Concealed pipeline; (B2) Switches and sockets; (B3) Exhaust duct line; (B4) Device renewal; (B5) Component updates; (C1) Storage space; (C2) Furniture renewal; (C3) Component form changes; (C4) Scale of activity space; (D1) Decoration style; (D2) Decoration component; (D3) Interior landscaping; (D4) Smart house system

* Questions unrelated to this article are not presented in the table.

Appendix B

Table A2. The questionnaire for architects.

Personal Information of Architects														
1. What is your name and job title? (Fill in the blank)														
2. Who is your employer? (Fill in the blank)														
3. How long have you been working in architectural design? (Fill in the blank)														
4. Do you have study or work experience abroad? (Single choice)	(1) Yes; (2) No													
5. How many residential design projects have you participated in? (Single choice)	(1) None; (2) 1–4; (3) 5–9; (4) 10 and more													
6. Do you have experience in interior design of housing? (Single choice)	(1) Yes; (2) No													
7. Have you ever considered flexibility in the design of residential buildings and interiors? (Single choice)	(1) Yes; (2) No													
8. Are you familiar with design concepts such as open buildings, SI housing, etc.? (Single choice)	(1) Yes; (2) No													
9. Do you know about housing-related parts and components, and their manufacturers? (Single choice)	(1) Yes; (2) No													
10. Contact information for follow-up consultation. (Fill in the blank)														
Evaluation of Flexible Design Strategies														
Name and explanation of strategy	How would you score the flexibility of this strategy? (Higher means better flexibility)							How would you score your intention to adopt this strategy? (Higher means greater intention)						
1. Wet and dry zoning. The potential water-use space and non-water-use space are divided in the layout to facilitate the reorganization of functions.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
2. Sectional descending board. The structural floor of the bathroom is lower than in other places, creating a certain height difference for the arrangement of pipelines.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
3. Same-floor drainage. Drainage and sewage pipes do not pass through the structural floor, and horizontal pipelines can be arranged in the floors to connect the main vertical pipes.	1	2	3	4	5	6	7	1	2	3	4	5	6	7

Table A2. *Cont.*

Personal Information of Architects														
4. Unit bathroom. Sanitary ware, finishes, pipelines, and waterproof layers required for the bathroom are integrated inside the unit box.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
5. Integrated kitchen. Cooking facilities, sanitary ware, pipelines, and finishes are integrated as a whole product, which is easy to disassemble and adjust.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
6. Horizontal exhaust. The flue gas is directly discharged to the exhaust port on the facade through horizontal pipes, without the need for a public flue well.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
7. External tube well. Traditional indoor tube wells (water, flue) are centrally arranged outside the layout, usually in public areas or outdoors.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
8. Horizontal structural component optimization. Horizontal structure beams or walls are arranged as far apart as possible on the exterior wall and the household-separating wall to reduce the impact on the spatial form.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
9. Vertical structural component optimization. Vertical structure columns or shear walls are arranged as far apart as possible on the exterior wall and the household-separating wall to reduce the impact on the spatial form.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
10. Modular coordination. Components and parts with a standardized modulus are selected in the design, along with a suitable modulus grid to facilitate the ease of construction and assembly.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
11. Universal space. Rooms are designed according to the unified standard, and each specific function is determined by the resident.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
12. Raised flooring system. The indoor floor is separated from the slab and the floor heating and other pipelines are arranged in the overhead layer, which can facilitate adjustment and maintenance.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
13. Light partition wall. A finished light wall panel or keel partition wall system is chosen to realize space division and decoration, which can facilitate disassembly or adjustment.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
14. Movable partition wall. Foldable or movable wall systems are chosen to realize the division of space and functions, which is convenient for space adjustment.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
15. Equipment assistance. Mechanical equipment is set up in the floors and walls, which can help to realize transformation by adjusting the space's form and size using an intelligent system.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
16. Pipeline separation. Pipelines are arranged in the overhead layer of raised floors and prefabricated walls, which will not damage the structure and can facilitate renovation.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
17. Space-saving cables and components. The use of small diameter or flat cables is directly combined with the decorative surface, which can save space and reduce the need for covering treatment for these cables.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
18. Order control. The order of construction is determined according to the usage life of components, where the short-lived components are easier to disassemble.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
19. Detachable construction. The decorative layer and other components of the wall are connected to the keel or the structure through a detachable interface.	1	2	3	4	5	6	7	1	2	3	4	5	6	7
20. Foldable furniture. The form of the furniture can be changed by folding, moving, deformation, etc., to adapt to different functional needs.	1	2	3	4	5	6	7	1	2	3	4	5	6	7

References

1. Feng, K. How to avoid "demolition and construction" in urban renewal? *Environ. Econ.* **2021**, *24*, 46–47.
2. Luo, J.; Huang, L. Spatio-temporal dialectical and value resetting: Consideration and discussion about the renovation of old urban community in China. *Urban Dev. Stud.* **2022**, *29*, 84–92.
3. Maslow, A.H. A theory of human motivation. *Psychol. Rev.* **1943**, *50*, 370. [CrossRef]
4. Liu, G.; Ye, K.; Tan, Y.; Huang, Z.; Li, X. Factors influencing homeowners' housing renovation decision-making: Towards a holistic understanding. *Energy Build.* **2022**, *254*, 111568. [CrossRef]
5. Goetz, E.G. Resistance to social housing transformation. *Cities* **2016**, *57*, 1–5. [CrossRef]
6. Xie, A. Status quo, trend and characteristics of population aging in China. *Stat. Res.* **2004**, *8*, 50–53.
7. Cheng, T.; Liu, C.; Yang, H.; Wang, N.; Liu, Y. From service capacity to spatial equity: Exploring a multi-stage decision-making approach for optimizing elderly-care facility distribution in the city centre of Tianjin, China. *Sustain. Cities Soc.* **2022**, *85*, 104076. [CrossRef]
8. Minami, K. The Efforts to Develop Longer Life Housing with Adaptability in Japan. *Energy Procedia* **2016**, *96*, 662–673. [CrossRef]
9. Altaş, N.E.; Özsoy, A. Spatial adaptability and flexibility as parameters of user satisfaction for quality housing. *Build. Environ.* **1998**, *33*, 315–323. [CrossRef]
10. Schneider, T.; Till, J. *Flexible Housing*; Architectural press: Oxford, UK, 2007.
11. Schneider, T.; Till, J. Flexible housing: Opportunities and limits. *Archit. Res. Q.* **2005**, *9*, 157–166. [CrossRef]
12. Groak, S. *The Idea of Building: Thought and Action in the Design and Production of Buildings*; E&FN Spon: London, UK, 1992.
13. Jia, B. *Housing in Long-Term Effectiveness: The New Thought of Contemporary Housing Design*; Southeast University Press: Nanjing, China, 1993.
14. Jia, B.; Wang, W. *Adaptable Housing Design*; Southeast University Press: Nanjing, China, 1998.
15. Leupen, B. *Frame and Generic Space*; 010 Publishers: Rotterdam, The Netherlands, 2006.
16. Leupen, B.; Jiang, Y. The polyvalence dwelling. *New Archit.* **2011**, *6*, 8–13.
17. Schmidt, R.; Austin, S. *Adaptable Architecture: Theory and Practice*; Taylor & Francis: New York, NY, USA, 2016.
18. Habraken, N.J. *Supports: An Alternative to Mass Housing*; Architectural Press: London, UK, 1972.
19. Kendall, S.H.; Teicher, J. *Residential Open Building*; Routledge: London, UK, 2010.
20. Cao, X.; Li, Z.; Liu, S. Study on factors that inhibit the promotion of SI housing system in China. *Energy Build.* **2015**, *88*, 384–394. [CrossRef]
21. Schmidt, R.; Eguchi, T.; Austin, S. Lessons from Japan: A Look at Century Housing System. In Proceedings of the 12th International Dependency and Structure Modelling Conference, Cambridge, UK, 22–23 July 2010.
22. Fukao, S.; Geng, X. The history of developments toward open building in Japan. *New Archit.* **2011**, *6*, 14–17.
23. Bostrom, J.A. *Adaptable Housing: A Technical Manual for Implementing Adaptable Dwelling Unit Specifications*; Diane Publishing Company: Collingdale, PA, USA, 1994.
24. Mace, R.L. Universal Design in Housing. *Assist. Technol.* **1998**, *10*, 21–28. [CrossRef] [PubMed]
25. Friedman, A. *The Grow Home*; McGill-Queen's University Press: Montreal, QC, Canada, 2001.
26. CMHC. *Flex Housing: Homes That Adapt to Life's Changes*; Canada Mortgage and Housing Corporation: Ottawa, ON, Canada, 1996.
27. Rooney, C.; Hadjri, K.; Rooney, M.; Faith, V.; McAllister, K.; Craig, C. Meeting the Needs of Visually Impaired People Living in Lifetime Homes. *J. Hous. Elder.* **2016**, *30*, 123–140. [CrossRef]
28. Liu, D.; Jiang, H.; Yu, L. Development of domestic housing industrialization and the technical evolution. *Archit. J.* **2012**, *4*, 10–18.
29. Ward, M.; Bringolf, J. Universal design in housing in Australia: Getting to yes. *Stud. Health Technol. Inform.* **2018**, *256*, 299–306.
30. De Paris, S.R.; Lopes, C.N.L. Housing flexibility problem: Review of recent limitations and solutions. *Front. Archit. Res.* **2018**, *7*, 80–91. [CrossRef]
31. Wu, C.; Thompson, M.E. *Sampling Theory and Practice*; Springer: Berlin/Heidelberg, Germany, 2020.
32. Ellis, P.D. *The Essential Guide to Effect Sizes: Statistical Power, Meta-Analysis, and the Interpretation of Research Results*; Cambridge University Press: Cambridge, UK, 2010.
33. Slaughter, E.S. Design strategies to increase building flexibility. *Build. Res. Inf.* **2001**, *29*, 208–217. [CrossRef]
34. Huang, J.; Zhou, J. Structural support and flexibility of residential plane. *Hous. Sci.* **2017**, *37*, 27–34.
35. Huang, J.; Zhou, J. Research on the types and characteristics of flexible housing. *Archit. J.* **2020**, *21*, 159–164.
36. Cho, S.H.; Lee, T.K. A study on building sustainable communities in high-rise and high-density apartments–Focused on living program. *Build. Environ.* **2011**, *46*, 1428–1435. [CrossRef]
37. He, B.J. Green building: A comprehensive solution to urban heat. *Energy and Buildings* **2022**, *271*, 112306. [CrossRef]
38. Zhao, D.X.; He, B.J.; Johnson, C.; Mou, B. Social problems of green buildings: From the humanistic needs to social acceptance. *Renew. Sustain. Energy Rev.* **2015**, *51*, 1594–1609. [CrossRef]
39. Wei, D.; Zhao, G.; Liu, S.; Yang, L. Indoor thermal comfort in a rural dwelling in southwest China. *Front. Public Health* **2022**, *10*, 1029390. [CrossRef]
40. Li, B.; Guo, W.; Liu, X.; Zhang, Y.; Caneparo, L. The Third Solar Decathlon China Buildings for Achieving Carbon Neutrality. *Buildings* **2022**, *12*, 1094. [CrossRef]
41. Li, B.; Guo, W.; Liu, X.; Zhang, Y.; Russell, P.J.; Schnabel, M.A. Sustainable Passive Design for Building Performance of Healthy Built Environment in the Lingnan Area. *Sustainability* **2021**, *13*, 9115. [CrossRef]