

The construction and quantification of rural housing performance evaluation index system

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Abstract: The performance evaluation index system of rural houses is put forward, considering of factors not only one of housing safety, comfort, convenience, and human nature , but also comprehensively four factors . By a lot of investigation, combined with the standards , building physics , the index is quantized to provide numerical value of the performance . The weight of each performance index is determined by Grey-AHP. Then the performance evaluation model of the rural houses is established to provide quantitative basis for housing performance evaluation.

1. Introduction

Rural housing is the basis for the lives of rural residents, and housing performance is directly related to the quality of residents' life and rural construction appearance. For a long time, China's rural housing construction process is such lack of design, construction guidance that rural housing exposed the two major problems, safety and comfort problem. Especially since 1990s, rural housing has a huge impact by urbanization, including housing demolition, local building demolition, city building elements invasion, causing destruction of the original culture and rural architectural style ^[1,2].

In this paper, the rural housing performance evaluation index is proposed and quantified. Then, the weight each index is determined by grey AHP and the rural housing performance evaluation model is established to provide quantitative basis for housing performance evaluation and promotion.

2. The construction of rural housing performance evaluation index system

Reasonable rural housing performance system is the key of housing performance evaluation and promotion. The selection of evaluation indicators should consider all aspects of the housing to ensure that the indicators are comprehensive, critical, oriented, operational.

Based on a lot of research on the performance of the existing rural housing, the major factors are reflected including the safety, comfort, convenience, humanization and comprehensive four performance , which are the goal of the evaluation to enhance the performance of the house. Primary indicators of housing performance include four second level index and twelve third level indicators, seeing Tab 1.

Tab 1 The performance evaluation index system of rural houses

First index U_0	Performance objectives of rural housing U													
Second index U_i	Safety performance U_1					Comfortable performance U_2					Convenient performance U_3		Humanizational performance U_4	
Third index U_{ij}	Struct-ure secur-ity U_{11}	Fire safety secur-ity U_{12}	Water secur-ity U_{13}	Electri-cal secur-ity U_{14}	Daily secur-ity U_{15}	Wind environ-ment U_{21}	Hot and humid environ-ment U_{22}	Light environ-ment U_{23}	Acoustic environ-ment U_{24}	Air quality U_{25}	Infrastr-ucture U_{31}	Indoor facilities U_{32}	Activity space U_{41}	Habits and custom U_{42}

3 The numerical quantification of rural housing performance index

By a lot of investigation, combined with the standards, building physics, the numerical value of the performance index is quantized to provide quantitative basis for the evaluation, Seeing Tab 2.

Tab2 Numerical quantization of performance indexes of village houses

Third index U_{ij}	Evaluation content (points)
Structure security U_{11}	<p>(1) Earthquake intensity: less than or equal to VI degrees , 2.5 points; VII degrees , 2 points ; VIII degrees , 1.5 points ; IX degrees , 1.5 points ; more than IX degrees , 0 points ;</p> <p>(2) The structure type: steel and reinforced concrete structure , 3 points; brick concrete structure, 2 points (if it has construction column and circle beam, +1 point); brick wood structure, 2 points; the other, 1 points;</p> <p>(3) Symmetry: for plane , symmetry ,1 point, asymmetric , 0 point; for elevation, symmetry , 0.5 points, asymmetry, 0 points;</p> <p>(4) Construction time: $Y \geq 2000$, 1 point ; $1990 \leq Y < 2000$, 0.5 point; $Y < 1990$, 0 point ;</p> <p>(5) Height /m : $h \leq 3.6$, 2 points; $3.6 < h \leq 7.2$, 1.5 points; $7.2 < h \leq 10.8$, 1point; $10.8 < h$, 0.5point;</p>
Fire safety U_{12}	<p>1) Fire protection system: for fire performance of decorative materials, A level , 2.5 points; A1 level , 2 points ; A2 level , 1.5 points, B1 level ,1 point ; B2 level , 0.5 point ; B3 level , 0 points; for ventilation and smoke exhaust system, natural ventilation , 1 point; mechanical exhaust , 0.5 point;</p> <p>(2) Fire extinguishing system: if has fire alarm device, 1 points; if has fire extinguishers, 1 points;</p> <p>(3) Safe evacuation system: safe exit, 1.5 points ; ordinary export , 0.5 points; emergency indicator or lighting, 1 point;</p> <p>(4) Management and others: strong personnal fire awareness , 2 points ; normal fire awareness , 1 point;</p>
Water security U_{13}	<p>(1)water quality: no color, 2 points; no smell , 2 points ; no precipitation, 2 points , otherwise 0.5 point;</p> <p>(2) water pipes, valves, buried pipe: no rust, 1 points otherwise 0.5 point; no leakage, 1 points, otherwise 0 points;</p> <p>(3) sewage treatment: organized sewer row , 1 points; disorderly row , 0.5 points;</p>
Electrical security U_{14}	<p>(1) Line design: for line spacing, orderly, 1 point, messy, 0.5 point ; for wire connection, galvanized copper joints , 1 point, sheep eye joints , 0.5 points; for the wire section, meet the load power , no fever , 2 points, fever, 0 point;</p> <p>(2) Grounding safety: bathroom, kitchen , etc. equipotential connection, 1 point;</p> <p>(3) Line protection: the protection measures of short circuit, overload, leakage, 2 points;</p> <p>(4) The degree of line aging: within 10 years , 1.5 points; 20~10 years, 1 point; more than 20 years, 0.5 point ;</p> <p>(5) Electrical safety awareness: no behavior about private pull chaos, the use of fake and shoddy electrical behavior ,1.5 points;</p>
Daily security U_{15}	<p>(1) The durability of decorative materials: for the durability life , more than 20 years, 3 points; 10~20 years , 2 points, less than 10 years, 1 point ;</p> <p>(2) Indoor floor antisliding measures, if has 2 points, otherwise 1 points;</p> <p>(3) Security measures: if has , 3 points, otherwise 1 point;</p>
Wind environment U_{21}	<p>(1) Outdoor natural wind environment under typical wind speed and wind direction: Winter: on the pedestrian zone around the building, the wind speed is less than 5m/s, and the outdoor wind speed amplification coefficient is less than 1.5, 2 points; Transition and summer season : no appear vortex or calm on people activity area, 2 points; the wind speed of the main function room within 0.5 ~ 1.4 m/s, 1 point;</p> <p>(2) Indoor natural wind environment under typical wind speed and wind direction: Transition and summer season : the wind speed of the main function room within 0.5 ~ 1.4 m/s , 4 points, within 0~0.5, 1.4 ~ 2 m/s, 3 points, and other , 1 point;</p>

Hot and humid environment U_{22}	(1) Thermal insulation material: for wall, if have, 2 points, otherwise 1; for roof, if have, 2 points, otherwise 1 point; for window, single glass, 0.5 point, hollow glass, 1 point, broken heat Aluminum Alloy, plastic steel, wooden, Aluminum Alloy frame, 1 points, iron frame, 0 points; (2) Adjustable shading measures (including fixed shading $\geq 30\text{cm}$): 3 points; (3) Condensation phenomenon, no 1 points;								
Light environment U_{23}	(1) Outdoor vision: front and rear direct spacing greater than 15m, get a score of 3; greater than 8m, get a score of 2; other points; (2) Window to floor ratio of the bedroom and sitting room, more than 1/5, 5 points; 1/6~1/5, 3 points; the other, 1 points; or directly measured indoor illuminance: for living room (hall), bedroom, study, kitchen, room center natural, illumination value is more than 300 lx, 3 points; for toilet, lobby, staircase, Dining Center, illumination value is more than 150 lx, 2 points; (3) Measures of glare control, if has, 2 points;								
Acoustic environment U_{24}		Outdoor acoustic environment A(dB)				Indoor acoustic environment (bedroom) B(dB)			
	Daytime	0~5 5	55~60	60~65	> 65	0~4 0	40~42. 5	42.5~4 5	45~50
	Score	4	3	2	1	4	3	2	1
	Night	0~4 5	45~50	50~55	> 55	0~3 0	30~33. 5	33.5~3 7	37~40
	Score	5	4	3	2	5	4	3	2
Note: the score is a sum of A and B, A, B is a smaller value between day and night.									
Air quality U_{25}	(1) The annual average value of PM2.5 : $\leq 50 \text{ mg/m}^3$, 2 points, 35~50 mg/m^3 , 1 point; (2) The hour average value of formaldehyde : $\leq 0.08 \text{ mg/m}^3$, 2 points, 0.08~0.12 mg/m^3 , 1 point; (3) The hour average value of radon : $\leq 200 \text{ Bq/m}^3$, 2 points; 200~400 Bq/m^3 , 1 point; (4) The hour average value of ammonia : $\leq 0.20 \text{ mg/m}^3$, 2 points; 0.20~0.50 mg/m^3 , 1 point; (5) The hour average value of benzene : $\leq 0.09 \text{ mg/m}^3$, 2 points; 0.09~0.12 mg/m^3 , 1 point;								
Infrastructure U_{31}	1) Public activity places like fitness places, supermarkets: if has, 3 points; (2) Centralized treatment places like waste water, garbage: if has, 2 points; (3) Public lighting of residential road : if has, 3 points; (4) The distance from the house to the bus station, less than 500m, 2 points, 500~1000m, 1 point;								
Indoor facilities U_{32}	(1) Air conditioner : if has, 3 points; (2) Photoelectric adjustment: if has, 3 points; (3) The use of solar hot water: if has, 4 points;								
Activity space U_{41}	(1) Courtyard area S: $S \geq 20\text{m}^2$, 4 points, $10\text{m}^2 \leq S < 20\text{m}^2$, 3 points; $S < 10\text{m}^2$, 2 points; (2) Room function layout: if it is conform to the local culture, 3 points, otherwise 1 point; (3) Public activity places like the temples, ancestral halls, theaters, etc. 3 points;								
Habits and customs U_{42}	(1) Courtyard houses, courtyard style houses, building style houses, if it is with, 4 points, otherwise 1 point; (2) The housing pattern, color, decoration and sculpture New Year paintings : if it reflects the local traditional culture, 3 points; otherwise 1 point; (3) The details of the housing structure like eaves, pick layer, screen head, base, door signs etc.: if it reflects the local traditional culture, 3 points, otherwise 1 point;								

4. The evaluation of rural housing performance

Set up: the weight of second index U_i is ω_i ; the weight of third index U_{ij} is ω_{ij} , corresponding sub score of it is Q_{ij} .

The weight of the housing performance indicators is determined by Grey-AHP^[8]. Specific as follows.

The weights of first index are $\omega^1 = (\omega_1, \omega_2, \omega_3, \omega_4) = (0.412, 0.281, 0.160, 0.147)$;

The weights of first index are $w_1^2 = (\omega_{11}, \omega_{12}, \omega_{13}, \omega_{14}) = (0.298, 0.172, 0.220, 0.231, 0.079)$;

$w_2^2 = (\omega_{21}, \omega_{22}, \omega_{23}, \omega_{24}) = (0.258, 0.264, 0.255, 0.111, 0.112)$;

$$w_3^2 = (\omega_{31}, \omega_{32}) = (0.523, 0.477);$$

$$w_4^2 = (\omega_{41}, \omega_{42}) = (0.444, 0.556)。$$

$$\text{The final score is : } W = \sum_{i=1}^4 (\omega_i \sum_{j=1}^4 \omega_{ij} Q_{ij})$$

5. Conclusion

(1) The rural housing performance evaluation index is proposed , including four second level index and twelve third level indicators.

(2) The performance index is quantized by a lot of investigation, combining with the standards, building physics, the numerical value of to provide quantitative basis for the evaluation.

(3) The weight of the housing performance indicators is determined by Grey-AHP.

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