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Civil building ventilation problem analysis

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ABSTRACT

With emergence and development of air conditioner technology, Chinese air conditioner technology has been further optimized in energy conservation and environmental protection aspects, so usage of air conditioner appears in every corner of modern buildings, some buildings even install integral central air conditioner, there are partial civil buildings install space to locate air conditioner for every users so as to keep standardized specification of whole floors. But excessive relying on air conditioner in view of energy and air, it not only causes wastes, but also leads to destroy natural environment in some aspects, so building ventilation problem should be further promoted. The paper firstly analyzes specified ventilation seasons or air conditioner seasons' building ventilation problems, and carries on fuzzy comprehensive evaluation on Chinese civil building's building ventilation problem from energy consumption aspect, improving residents' comfort level, spatial arrangement and building techniques aspect.

KEYWORDS

Building ventilation; Fuzzy comprehensive evaluation; Civil building.

INTRODUCTION

By TABLE 1 and TABLE 2, the paper states civil building, office building and store building three main buildings' dehumidification main coefficients by ventilation ways and different functions' spaces required ventilation ways.

TABLE 1 : Building dehumidification coefficient

Computation parameter	Civil building	Office building	Store building
Dehumidification coefficient g/h	102	102	176

TABLE 2 : Ventilation rate

Type of building	Type of room	Average ventilation rate
Civil building	Ordinary building	17
	Detached building	15
Store building	General stores	12
Office building	Regular office	19
	Top-level office	15
	Meeting room	20
	File room	10
	Corridor	6

By TABLE 3, it is clear that different seasons have different requirements in ventilation, according to different seasons, local direction and wind speed have great differences, so take comprehensive consideration of ventilation seasons time, it mainly considers the seasons ventilation problems and analyzes civil building ventilation designing.

TABLE 3 : Different seasons to ventilation

Building energy conservation seasons	Starting date	Ending date	Consecutive days
Ventilation seasons	1.1	5.23	143
	10.5	12.31	88
Dehumidification seasons	5.24	6.20	28
	9.18	10.4	17
Air conditioner seasons	6.21	9.17	89

FUZZY EVALUATION MODEL ESTABLISHMENTS

Fuzzy comprehensive evaluation model

Fuzzy comprehensive evaluation model fits for fuzzy computation that multiple factors are uncertain, the paper utilizes fuzzy comprehensive evaluation, and it gets following process:
At first, the paper establishes factor set U :

$$U = (U_1 \quad U_2 \quad \cdots \quad U_k)$$

Secondly, establish factor set V (evaluation set),

The paper establishes evaluation matrix fuzzy mapping from U to V , obtained fuzzy relation as following matrix show:

$$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

The paper establishes weight set, $A=(a_1,a_2,\cdots,a_n)$, it meets conditions:

$$\sum_{i=1}^{n} a_i = 1 \quad a_i \geq 0$$

Fuzzy relation R every line will reflect the line influence factors to object judgment degree, meanwhile, R every column will reflect the column influence factors to object judgment degree.

$$\sum_{i=1}^{n} r_{ij} \quad j=1,2,3,\cdots,m$$

Secondly the paper carries on following computation according to fuzzy comprehensive evaluation:

$$\begin{aligned} B &= A\cdot R \\ &= (a_1,a_2,a_3,\cdots,a_n)\cdot\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \\ &= (b_1,b_2,b_3,\cdots,b_n) \end{aligned}$$

In V, fuzzy combination is evaluation set B. To sum up, actually fuzzy comprehensive evaluation obtained multimode system simple change model is as Figure 1 shows:

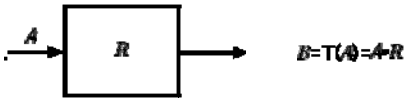

Figure 1 : Simple change model

According to Figure 1 marked contents, it gets fuzzy comprehensive evaluation change model, and can establish corresponding every factor grade evaluation transformation function, evaluation factors u1, u2, u3, u4, u5 membership functions can be expressed as following formula (1), (2), (3) shows:

$$u_{v1}(u_1)=\begin{cases} 0.5(1+\dfrac{u_i-k_1}{u_i-k_2}), & u_i \geq k_1 \\ 0.5(1-\dfrac{k_1-u_i}{k_1-k_2}), & k_2 \leq u_i < k_1 \\ 0 \quad , & u_i < k_2 \end{cases} \tag{1}$$

$$u_{v2}(u_1)=\begin{cases}0.5(1-\dfrac{u_i-k_1}{u_i-k_2}), & u_i \ge k_1\\ 0.5(1+\dfrac{k_1-u_i}{k_1-k_2}), & k_2 \le u_i < k_1\\ 0.5(1-\dfrac{u_i-k_3}{k_2-k_3}), & k_3 \le u_i < k_2\\ 0.5(1-\dfrac{k_3-u_i}{k_2-u_i}), & u_i < k_3\end{cases} \quad \textbf{(2)}$$

$$u_{v1}(u_1)=\begin{cases}0, & u_i \ge k_2\\ 0.5(1-\dfrac{k_1-u_i}{k_2-k_3}), & k_3 \le u_i < k_2\\ 0.5(1+\dfrac{k_3-u_i}{k_2-u_i}), & u_i < k_3\end{cases} \quad \textbf{(3)}$$

Combine with fuzzy evaluation model to evaluate civil building ventilation problem

By above model principle, it establishes factor set U, from which $U=(U_1 \quad U_2 \quad U_3 \quad U_4)$. Among them, energy consumption aspect U_1, improving residents comfort level U_2, spatial arrangement U_3, building techniques U_4, it gets TABLE 4. The paper establishes small factors sets in four important factor sets.

TABLE 4 : Civil building ventilation problem evaluation indicator system

Energy consumption aspect U_1	Improving residents comfort level U_2	Spatial arrangement U_3	Building techniques U_4
Air conditioner usage amount u_{11}	Ventilation efficiency u_{21}	Conform to building mechanics u_{31}	Ventilation designing cost u_{41}
Improvement of air index u_{12}	Ventilation quality u_{22}	Indoors spatial arrangement u_{32}	Installation techniques u_{42}
Clearstory or ventilator utilization u_{13}	Summer ventilation efficiency u_{23}	Ventilation lighting requirements u_{33}	New pattern technical development u_{43}
Reduction of electricity consumption u_{14}	Building ventilation and lighting set u_{24}	Overall situation arrangement u_{34}	
Change of ventilation facilities u_{15}			

By TABLE 4 listed factors, it gets evaluation set.

$$U_1=\{u_{11},u_{12},u_{13},u_{14}\}$$
$$U_2=\{u_{21},u_{22},u_{23},u_{24},u_{25}\}$$
$$U_3=\{u_{31},u_{32},u_{33}\}$$
$$U_4=\{u_{41},u_{42},u_{43},u_{44}\}$$

By collecting data and analyzing, it gets four factors importance degree ranking statistics as TABLE 5 shows.

TABLE 5: Four factors importance degree ranking statistics

Classification	Rank 1	Rank 2	Rank 3	Rank 4
Energy consumption aspect U_1	23	7	3	0
Improving residents comfort level U_2	0	0	15	18
Spatial arrangement U_3	0	9	13	12
Building techniques U_4	3	21	9	0

By TABLE 2 sorting, it gets energy consumption aspect U_1, improving residents comfort level U_2, spatial arrangement U_3, building techniques U_4 four aspects ranking matrix.

$$U_2 = \{23,7,3,0\}$$
$$U_2 = \{0,9,15,18\}$$
$$U_3 = \{0,9,13,12\}$$
$$U_4 = \{3,21,9,0\}$$

Obtained weighted vector from rank 1 to rank 2

$$\beta = \{\beta_1, \beta_2, \beta_3, \beta_4\} = \{0.4, 0.3, 0.2, 0.1\}$$

According to following process, it gets

$$U_i^* = U_i \cdot \beta^T$$
$$U_1^* = 14,\ U_2^* = 9.4,\ U_3^* = 4,\ U_4^* = 5.6$$

The paper takes normalization processing, and gets:

$$U_1^* = 0.35,\ U_2^* = 0.3,\ U_3^* = 0.2,\ U_4^* = 0.15$$
$$\bar{A} = (0.35 \quad 0.3 \quad 0.2 \quad 0.15)$$

The paper establishes remarks membership, as TABLE 6 show.

TABLE 6 : Remarks membership

Evaluation way	Set scores interval			
	0-60	60-80	80-90	90-100
Very good	0	0	0.05	0.95
Good	0	0.05	0.9	0.05
Normal	0.05	0.9	0.05	0
Bad	0.95	0.05	0	0

The paper gets TABLE 7 through obtained evaluation on Chinese civil building ventilation problem in energy consumption aspect U_1, improving residents comfort level U_2, spatial arrangement U_3, building techniques U_4 four aspects each indicator.

TABLE 7 : Chinese civil building ventilation problem each item indicator obtained evaluation value

Each layer indicator	Evaluation value	Each layer indicator	Evaluation value
Relative air conditioner usage amount u_{11}	Good	Conform to building mechanics u_{31}	Good
Improvement of air index u_{12}	Normal	Indoors spatial arrangement u_{32}	Good
Clearstory or ventilator utilization u_{13}	Normal	Ventilation lighting requirements u_{33}	Good
Reduction of electricity consumption u_{14}	Normal	Overall situation arrangement u_{34}	Normal
Change of ventilation facilities u_{15}	Normal	Ventilation designing cost u_{41}	Good
Ventilation efficiency u_{21}	Very good	Installation techniques u_{42}	Normal
Ventilation quality u_{22}	Very good	New pattern technical development u_{43}	Normal
Summer ventilation efficiency u_{23}	Good		
Building ventilation and lighting set u_{24}	Good		

By above model, it gets single layer indicator weight factor fuzzy set is:

$$U_1^* = \{U_{11}, U_{12}, U_{13}, U_{14}, U_{15}\} = \{0.25\ 0.24\ 0.21\ 0.14\ 0.16\}$$
$$U_2^* = \{U_{21}, U_{22}, U_{23}, U_{24}\} = \{0.53\ 0.11\ 0.24\ 0.14\}$$
$$U_1^* = \{U_{31}, U_{32}, U_{33}, U_{34}\} = \{0.42\ 0.28\ 0.1\ 0.2\}$$
$$U_1^* = \{U_{41}, U_{42}, U_{43}\} = \{0.3\ 0.39\ 0.31\}$$

The paper relies on TABLE 5 evaluation, combines with TABLE 3 remarks membership, it gets energy consumption aspect U_1, improving residents comfort level U_2, spatial arrangement U_3, building techniques U_4 each aspect evaluation set:

Energy consumption aspect $U_1 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.95 & 0.05 \\ 0 & 0.05 & 0.95 & 0.05 \\ 0 & 0.05 & 0.95 & 0.05 \end{pmatrix}$

Improving residents comfort level $U_2 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$

Spatial arrangement $U_3 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0.05 & 0.9 & 0.05 & 0 \end{pmatrix}$

Building techniques $U_4 = \begin{pmatrix} 0 & 0 & 0.05 & 0.95 \\ 0 & 0.05 & 0.9 & 0.05 \\ 0 & 0.05 & 0.9 & 0.05 \end{pmatrix}$

Carry on following computation on above evaluation set:

$$B_i = A_i \cdot R_i$$

Make normalization processing with obtained B_i, it gets fuzzy evaluation matrix.

$$\bar{B} = \begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{pmatrix} = \begin{pmatrix} 0.07 & 0.26 & 0.13 & 0.42 \\ 0 & 0.15 & 0.76 & 0.54 \\ 0.14 & 0.24 & 0.21 & 0.17 \\ 0.14 & 0.2 & 0.3 & 0.36 \end{pmatrix}$$

It gets comprehensive evaluation value:

$$Z = U^* \cdot B = \begin{pmatrix} 0.24 & 0.33 & 0.28 & 0.15 \end{pmatrix}$$

CONCLUSION

By fuzzy comprehensive evaluation value, it can get that 0.33 maximum value located remark is good, which shows that in energy consumption aspect, improving residents' comfort level, spatial arrangement and building techniques aspect as well as other aspects develop well, but due to 0.28 gets closer to 0.33, it shows civil building ventilation problem development is not smooth, it needs to make further improvements in designing and constructing aspects, and better implements high quality ventilation.

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