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Evaluation of Railway Green Construction Scheme Based on Interval Number Attribute Connection Degree

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Abstract: Railway green construction is one of the important measures to realize the sustainable development of railway. At present, the research on the evaluation standard of railway green construction is still in the exploration stage. Based on the "green construction evaluation standard of construction engineering", considering the characteristics of railway construction On the basis of this, an evaluation method of railway green construction scheme is put forward, and the evaluation of green construction scheme is realized. With reference to the relevant green construction standards and domestic and foreign research results, to build the railway green construction stage evaluation index system. The interval range of the index is determined by the interval hierarchy analysis method. Secondly, the index interval is transformed into the interval number matrix, and then transformed into the contact number matrix, and the interval multi-attribute railway green evaluation based on the number of links is established. model. The model determines the relative proximity of each green construction scheme by calculating the final comprehensive contact number, and determines its merits by sorting. Finally, through the example verification, the optimal green construction scheme of intercity railway of Lanzhou to Nakagawa Airport is obtained. The advantage of this method is that it is more reasonable to use the interval number to describe the possible range of the index than the simple numerical representation, so that the evaluation result is more accurate and more reference.

In recent years, China's economic and social development of good and fast, the railway as a major artery of the national economy, the state's important infrastructure and popular transport, its backbone position has become increasingly prominent. In order to realize the sustainable development in the course of railway construction and promote the construction of resource - saving and environment - friendly railway, we must pay attention to the application of "green" technology in railway construction. To this end, as soon as possible to establish China's green railway evaluation standards for the standardization and guidance of modern railway construction, will become the inevitable development of China's railway industry and needs.

At present, there are few researches on the evaluation of high-speed railway construction from green angle, and the evaluation theory and methods need to be improved constantly. Xiong Feng[1] and so on to explore the necessity of sustainable development of green railway; Ding Leilei[2] and so on to Beijing-Shanghai high-speed railway as the research object, the basic theory of green development to sort out, and based on green theory and high-speed railway construction link to evaluate its green development level;Bao Xueying[3] and so on "green construction evaluation

standards" Based on the deep consideration of the characteristics of green railway construction, this paper puts forward a kind of evaluation method of railway green construction grade, realizes the evaluation of railway green construction grade, provides technical support for standardizing the construction of domestic railway green; Zhang Junqiang[4] Multi-model integrated green construction scheme evaluation method, the green construction program for the merits of the evaluation study. At present, scholars in the railway green construction program evaluation method put forward a lot of innovation.

Green construction program is to guide the railway green construction technology and guidance documents, is to create the whole life cycle "green railway" an important part of its advantages and disadvantages of the implementation of green construction has a decisive role, related to the advantages and disadvantages of green construction evaluation The To evaluate the construction plan of the green railway, we must first determine the weight of the evaluation index system. At present, the mature subjective weighting method at home and abroad has AHP, Delphi and so on, but it is often not unified Of the standard, easily influenced by the subjective consciousness of the decision maker. Compared with the construction project, the railway as a linear distribution of the transport system has its obvious particularity, due to the complex construction organization, concealment, unknown uncertainty factors, poor operating environment, and the impact on the surrounding environment, taking into account The attribute description of railway green construction scheme is complex and uncertain. Attribute description can not be given in the form of numerical point. Therefore, it is more reasonable to use interval number to describe the possible range of index than to use simple numerical representation.

In this paper, we use the interval number attribute linkage degree method to solve the problem that the subjective weight of the index is not considered to be accurate enough, and the interval weight of each index is determined. Finally, the relative settlement of each construction scheme is determined And the advantages and disadvantages of the order, the optimal construction program.

To establish a railway green construction stage evaluation index system

Selection of evaluation indicators

As the current green evaluation in the construction phase of the railway is still in the exploratory stage, so the selection of evaluation indicators in this reference in the "green construction evaluation standards for construction", "green railway theory and evaluation", "Ministry of Railways on the issuance of railway projects in 2013 Construction of the standard preparation plan notice "(iron construction letter [2013] 39) and other standards and domestic and foreign research results on the basis of China's green railway to determine the evaluation of indicators.

The evaluation contents of the "Green Construction Evaluation Standard for Construction Engineering" include water saving, land saving, energy saving, materials and environmental protection. The evaluation system is based on the characteristics of railway construction and the conditions of geological, natural environment, economy, folk custom and transportation. It is divided into three levels: the first layer is the target layer U, the evaluation index system for the railway green construction stage, the second layer is the criterion layer, , which consists of five secondary index layers, including environmental managementU_1, environmental protection measureU_2, water conservation measuresU_3, environment Pollution controlU_4, energy savingU_5; the third layer for the program layer, a total of 15 three indicators.

Establish an evaluation index system

Based on the relevant green building and green construction national standard, this paper constructs environmental management, environmental protection measures, water conservation measures and environmental pollution control, taking into account the opinions of construction units, supervision units, construction units and green building related experts. And energy saving (energy consumption) 5 aspects of the railway green construction program evaluation indicators, as shown in Table 1.

Environmental management: from the management level to coordinate the entire green construction process, the evaluation indicators, including environmental protection measures to improve the degree of environmental protection agencies to improve the degree of sound, in order to achieve the railway green targets and the development of environmental protection rules and regulations to improve the implementation of The situation, as well as the construction site staff environmental knowledge training and environmental warning signs of the popularity of the root causes to reduce the environmental awareness caused by the unnecessary pollution.

Table 1 Evaluation index of railway green construction projects

Level 1 indicators	Secondary indicators		Level 3 indicators	
Iron road Green color Application Work Order segment Comment Price Means Standard body system U	Environmental management	U_1	Construction design	U_{11}
			Rules and regulations	U_{12}
			Institutional settings	U_{13}
			Environmental protection knowledge training, logo popularity	U_{14}
	Environmental protection measures	U_2	Temporary environmental protection measures	U_{21}
			Permanent environmental protection measures	U_{22}
	Water conservation measures	U_3	Temporary water conservation measures	U_{31}
			Permanent water conservation measures	U_{32}
	Environmental Pollution Control	U_4	noise	U_{41}
			shock	U_{42}
			Solid Waste	U_{43}
			Sewage	U_{44}
			Exhaust gas	U_{45}
	Energy saving (Energy consumption)	U_5	Power consumption	U_{51}
			Oil consumption	U_{52}

Environmental protection measures: the development of effective environmental protection measures can be in advance to prevent environmental pollution, such as the bridge pile mud treatment facilities to improve the degree of sewage, dust, noise and other temporary protection measures to improve the degree.

Soil and Water Conservation Measures: Soil and Water Conservation Measures Including Temporary Soil and Water Conservation Measures and Permanent Soil and Water Conservation Works, Temporary Soil and Water Conservation Measures such as surface soil stripping, temporary stacking and improvement of protective measures; improvement of temporary drainage facilities in construction sites; Measures to improve the degree of permanent water conservation measures, including the degree of improvement of soil and water conservation projects and the improvement of land reclamation projects.

Environmental pollution control: the impact of railway construction on the surrounding ecological environment mainly noise, vibration, solid waste, waste water discharge and waste. Therefore, it can be judged by the rate of governance.

Energy consumption (energy consumption): including energy consumption and oil consumption, power consumption, including the production of electricity consumption and living energy consumption, oil consumption, including the construction process of vehicle transportation and energy consumption of construction equipment fuel[5].

Determine the weight of evaluation indicators

As an important part of the evaluation model, weight plays an important role in the evaluation process. According to the different weights of the evaluation index, the weighting method can be divided into two categories, subjective weighting method and objective weighting method. From the index system shown in Table 1, it can be seen that some of the evaluation indicators are quantitative indicators, some are qualitative indicators, the traditional AHP method can be used to determine the weight of the index, but because of the uncertainty of the information being evaluated, It is necessary to use the interval mathematics to describe the subjective judgment value accurately, and it is necessary to describe the subjective judgment value accurately. In this case, it is reasonable to use the interval AHI to describe the subjective judgment value accurately. Determine the weight of index by interval analytic hierarchy process.

This method is used to solve the weight of each level index because of the simplicity of the calculation method of the interval feature method in the method of interval analytic hierarchy process [6]. The specific calculation steps of the method are:

(1) Find the normalized eigenvectors x^+ and x^- with positive components corresponding to the largest eigenvalues of matrices A^+, A^-, respectively.

(2) Calculate the values of k and m from $A^+ = (a_{ij}^+)_{n\times n}$ and $A^- = (a_{ij}^-)_{n\times n}$,A known that：

$$k = \sqrt{\sum_{j=1}^{n} \frac{1}{\sum_{i=1}^{n} a_{ij}^+}} \quad m = \sqrt{\sum_{j=1}^{n} \frac{1}{\sum_{i=1}^{n} a_{ij}^-}} \tag{1}$$

(3) Seeking interval weight vector:

$$W = [kx^-, mx^+] \tag{2}$$

According to the evaluation system of railway green construction stage, the judgment matrix of 1 ~ 9 ratio is introduced, and the judgment matrix of each layer is constructed by expert scoring. By comparing the five secondary indexes and 15 third indexes respectively, In the respective overall goal of two pairs of scoring, and thus calculate the criteria layer and the program layer interval judgment matrix and weight. (Limited to space, where only the interval matrix and weight of the criterion layer and scheme layer U_1 are listed.)

Table 2 Interval Judgment Matrix and Weight of Each Index Of Criteria layer

Indicator item	U_1	U_2	U_3	U_4	U_5	U_6	x^+	K，M	w
U_1	[1,1]	[1/5, 1/3]	[1/3, 1/2]	[2,3]	[3,5]	0.1381	0.1440		[0.1282,0.1527]
U_2	[3,5]	[1,1]	[2,3]	[5,7]	[7,8]	0.4804	0.4734	K=0.9285	[0.4461,0.5019]
U_3	[2,3]	[1/3, 1/2]	[1,1]	[3,5]	[5,7]	0.2615	0.2659	M=1.0602	[0.2428,0.2819]
U_4	[1/3, 1/2]	[1/7, 1/5]	[1/5, 1/3]	[1,1]	[2,3]	0.0756	0.0755		[0.0702,0.0800]
U_5	[1/5, 1/3]	[1/8, 1/7]	[1/7, 1/5]	[1/3, 1/2]	[1,1]	0.0444	0.0412		[0.0412,0.0437]

Table 3 Interval Judgment Matrix and Weight of Index Of Program layer U_1

	U_{11}	U_{12}	U_{13}	U_{14}	x^-	x^+	K，M	w_1
U_{11}	[1,1]	[2,3]	[5,7]	[3,5]	0.5258	0.5237	K=0.9308	[0.4894,0.5562]
U_{12}	[1/3,1/2]	[1,1]	[3,5]	[2,3]	0.2675	0.2698	M=1.062	[0.2490,0.2865]
U_{13}	[1/7,1/5]	[1/5,1/3]	[1,1]	[1/3,1/2]	0.0706	0.0696		[0.0657,0.0739]
U_{14}	[1/5,1/3]	[1/3,1/2]	[2,3]	[1,1]	0.1361	0.1369		[0.1267,0.1454]

Interval number multiple attribute contact number evaluation model

Evaluation model selection

As can be seen from Table 1, there are many factors that affect the green construction of the railway, and the impact of various factors is unknown, so the railway green construction program evaluation should belong to the gray system category. And the interval attribute association degree is the same analysis of the characteristics of the two sets *A* and *B* with certain relation. The relationship between the two sets is explained from the same, the opposite and the reverse, and the relationship between the two sets is determined. , To determine whether the railway construction program is green. So it is possible to evaluate the railway green construction scheme according to the interval degree attribute association degree.

Specific steps to build an evaluation model

Establish the number of contact expression

In 1989, Zhao Keqin put forward the theory of set pair analysis. The basic idea is to combine two sets *A*,*B* with certain relations in the context of specific problems, and to form a pair *H=(A,B)* as a set pair, and to oppose the characteristics of the two sets The same analysis[7].

$$m(H,W)=\frac{S}{N}+\frac{F}{N}i+\frac{P}{N}j \qquad (3)$$

This theory explains the relationship between the two sets and their interrelations from the

same, different and inverse aspects. The expression of the set and the number of connections is:

Where *S/N* , *F/N* and*P/N* represent "the same degree" and "degree of difference" and "the degree of opposition", respectively, in general, by a, b, c, and abbreviated as $\mu=a+b_i+c_j$, and a+b+c=1, For the difference of the coefficient, take i= [-1,1]; j is the coefficient of the degree of alignment, take j = -1[8].

Build multi-attribute interval matrix

Assuming that the scheme set consists of m rail green construction schemes: $X=\{X_1,X_2,...X_m\}$,each program has multiple attribute indicators, the index set is $I=\{I_1,I_2,...I_n\}$, each of which is composed of interval number, defined as$I_l=[i^-,i^+]$, And $i^-\leq i^+$, then the interval number matrix is as follows:

$$X=\begin{bmatrix}[i_{11}^-,i_{11}^+] & \mathbf{L} & [i_{1n}^-,i_{1n}^+]\\ \mathbf{M} & \mathbf{O} & \mathbf{M}\\ [i_{m1}^-,i_{m1}^+] & \mathbf{L} & [i_{mn}^-,i_{mn}^+]\end{bmatrix} \quad (4)$$

Calculate the ternary connection number matrix

Set the attribute index interval $i_{kr}=[i^-_{kr},i^+_{kr}]$ of the scheme X_K, which can be converted into $u_{kr}=a_{kr}+b_{kr}i+c_{kr}j$ according to the set pair analysis theory, among which $a_{kr}=i^-_{kr}$、$b_{kr}=i^+_{kr}-i^-_{kr}$、$c_{kr}=1-i^+_{kr}$are the same degree, the degree of difference and the degree of opposition[12]. After the conversion of the degree of contact matrix is:

$$U_X=\begin{bmatrix}a_{11}+b_{11}i+c_{11}j & \mathbf{L} & a_{1n}+b_{1n}i+c_{1n}j\\ \mathbf{M} & \mathbf{O} & \mathbf{M}\\ a_{m1}+b_{m1}i+c_{m1}j & \mathbf{L} & a_{mn}+b_{mn}i+c_{mn}j\end{bmatrix} \quad (5)$$

Determine the distance between connections

According to the definition of *C** in TOPSIS solution, we construct the absolute ideal solution and the absolute negative ideal solution. The absolute ideal solution of scheme X_K is: $X^+=\{u^+,u^+=1+0i+0j,1\leqq r\leqq n\}$; the absolute negative ideal solution is: $X^-=\{u_r^-,u_r^-=0+0i+j,1\leq r\leq n\}$

The distance between the scheme attribute index and the absolute ideal solution and the absolute negative ideal solution are:

$$c^+=\sum_{r=1}^{n}\sqrt{(1-a_r)^2+b_r^2+c_r^2} \quad (6)$$

$$c^-=\sum_{r=1}^{n}w_r\sqrt{a_r^2+b_r^2+(1-c_r)^2} \quad (7)$$

According to (6), (7) the relative degree c can be obtained as follows:

$$C=C^-/(C^++C^-) \quad (8)$$

The greater the relative degree of closeness, the better the green scheme[9].

Example validation

Lanzhou to Nakagawa Airport intercity railway opened on September 30, 2015, is a section of the blue fast railway, radiation Gansu Hexi region. Line length of 63 km, EMU 160-200 km per hour, across the board set Lanzhou West Railway Station, Chen Guan camp, welfare area, Xigu, Lanzhou New District and Nakagawa Airport a total of six stations. In order to implement the "green railway" concept, the project investors and the construction side to develop four sets of railway green construction program, organization of construction units, supervision units and green building related industries 10 experts on these four programs to score, Calculation, the score into 0 to 1, the results shown in Table 4.

Table 4 Interval Value of Attributes of Railway Construction Schemes

Program	U_{11}	U_{12}	U_{13}	U_{14}	U_{21}
A	[0.842,0.863]	[0.863,0.892]	[0.853,0.900]	[0.863,0.875]	[0.763,0.796]
B	[0.833,0.884]	[0.784,0.852]	[0.792,0.830]	[0.852,0.903]	[0.803,0.858]
C	[0.890,0.920]	[0.804,0.850]	[0.732,0.764]	[0.783,0.804]	[0.660,0.733]
D	[0.860,0.880]	[0.870,0.890]	[0.765,0.803]	[0.798,0.848]	[0.824,0.878]

Program	U_{22}	U_{31}	U_{32}	U_{41}	U_{42}
A	[0.846,0.890]	[0.788,0.814]	[0.853,0.882]	[0.765,0.783]	[0.772,0.815]
B	[0.852,0.910]	[0.866,0.893]	[0.862,0.923]	[0.800,0.843]	[0810,0.865]
C	[0.765,0.822]	[0.832,0.854]	[0.841,0.877]	[0.655,0.703]	[0.769,0.834]
D	[0.876,0.918]	[0.896,0.932]	[0.899,0.943]	[0.732,0.800]	[0.655,0.732]

Program	U_{43}	U_{44}	U_{45}	U_{51}	U_{52}
A	[0.780,0.833]	[0.890,0.943]	[0.833,0.846]	[0.732,0.796]	[0.810,0.833]
B	[0.833,0.895]	[0.923,0.956]	[0.868,0.894]	[0.760,0.800]	[0.776,0.805]
C	[0.804,0.855]	[0.867,0.933]	[0.866,0.890]	[0.815,0.863]	[0.860,0.903]
D	[0.804,0.843]	[0.834,0.865]	[0.805,0.864]	[0.744,0.783]	[0.764,0.795]

Interval weights are converted to deterministic weights

The criteria layer and the program layer in the index of the weighted range of weight into a certain weight: $W^*=\{w_1^*,w_2^*...,w_n^*\}$. Since all the interval weights are given by the same system, the same decision maker, or the decision maker, it is assumed that the deviation ratio e of the upper and lower bounds of each index interval given by the same system is constant for its target weight, e is a constant.

$$d_r^- / d_r^+ = e, \forall r \in \{1, \mathbf{L}, n\} \tag{9}$$

$$e = d_r^- / d_r^+ = \sum_{r=1}^{n} d_r^- / \sum_{r=1}^{n} d_r^+ = (1 - \sum_{r=1}^{n} w_r^-) / (\sum_{r=1}^{n} w_r^+ - 1) \tag{10}$$

$$w_r^* = w_r^- + c/(c+1) \times (w_r^+ - w_r^-) = w_r^- + (1 - \sum_{r=1}^{n} w_r^-) / (\sum_{r=1}^{n} w_r^+ - \sum_{r=1}^{n} w_r^-) \times (w_r^+ - w_r^-) \tag{11}$$

Railway green construction program comprehensive evaluation

Through the interval multi-attribute contact number model, the evaluation of the merits and demerits of the selected four green railway construction schemes is evaluated.

1) According to Table 2, Table 3 and other program layers of the interval judgment matrix and the weight of the data, combined with the formula (10) and formula (11), the calculation of deterministic weight, available:

w=(0.0467,0.0385,0.0030,0.0180,0.0429,0.2484,0.0429,0.2484,0.0104,0.0107,0.0319,0.0206, 0.0531,0.0221,0.1624)

2) According to the formula (4), the index interval in Table 4 is constructed as the interval matrix, and then converted into the number of connection matrix, because the space is limited, this matrix is not listed here.

3) According to the deterministic weight and the number of links to obtain the number of comprehensive contact, as shown in equation (12):

$$m = w \times m_p = \sum_{r=1}^{n} w_r (a_{pr} + b_{pr} i + c_{pr} j) = \sum_{r=1}^{n} w_r a_{pr} + \sum_{r=1}^{n} w_r b_{pr} i + \sum_{r=1}^{n} w_r c_{pr} j \tag{12}$$

4) According to the formula (6), the formula (7), the formula (8) can be obtained and the final results shown in Table 5.

Table 5 Evaluation Results of Railway Green Construction

Program	Comprehensive number of contacts$U$	C^+	C^-	$C=C^-/(C^++C^-)$
A	0.8306+0.0324i+0.1370j	0.2211	1.2315	0.8478
B	0.8356+0.0269i+0.1156j	0.2083	1.3587	0.8671
C	0.8140+0.0438i+0.1146j	0.3244	1.1855	0.7852
D	0.8457+0.0404i+0.1161j	0.1985	1.1842	0.8564

Conclusion

1) Using the interval hierarchy analysis method to determine the weight of the index, fundamentally improve the previous method to evaluate the index as a simple numerical to determine the weight of the drawbacks, give full play to the advantages of interval level analysis method, more objective and accurate to determine the weight of the index.

2) Based on the theory of connection number in set pair analysis, this paper constructs the interval number multi-attribute linkage number model and combines the index weight, and gives the evaluation method of green construction scheme based on the number of connection distance. Then, through the evaluation model, Green program to verify, and obtain a scientific and reasonable evaluation results.

3) The results of this study can provide some theoretical basis for the scheme selection of railway green construction stage, and provide reference for the development of railway green construction evaluation standard.

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