[1]Ce Sha

[1]Yaoyao Huang

[2]Yunlou Qian

[1]Kaikai Jin

Study on Safety Evaluation Method of Groundwater for Extra - large Corridor Backfill Karst Tunnel

Abstract: - The groundwater has a significant on the construction of the large-scale corridor back-type karst tunnels, so it is particularly essential to carry out safety evaluation. In view of the technical problems of groundwater safety evaluation in the construction of large-scale corridor back-type karst tunnels, this paper uses BP neural network combines with AHP analysis to determine the weight of each index on the basis of the characteristics of backfill and evaluation criteria. Furthermore, the fuzzy evaluation model of groundwater safety for backfill karst tunnels is established, and a new method of groundwater safety evaluation for large-scale corridor backhoe-type karst tunnels is proposed. The results of the case study show that the results of the evaluation of groundwater safety of the large-scale backhoe-type karst tunnels are consistent with the engineering practice, which show that the evaluation index system and the evaluation method adopted in this paper are reasonable, and can provide reference for the safety evaluation of groundwater environment similar to tunnel engineering.

Keywords: cave ; tunnel ; groundwater ; BP neural network ; AHP

1 Introduction

With the increasingly extensive construction of transportation infrastructure, it is inevitable to encounter super-large karst tunnels in the process of tunnel excavation. The development of karst tunnel construction in our country is restricted by the harm of groundwater, and it can cause casualties and economic losses. Therefore, how to evaluate the safety of groundwater in the backfilling karst tunnel with extra-large corridor hall and modify the design on this basis and reduce the risk has become a technical problem in engineering construction.

The safety of groundwater in super-large backfill karst tunnel is mainly affected by the characteristics of karst cave and backfill, physical geography, geology, hydrogeology, tunnel structure and so on. Based on this understanding, Liu Jian et al. [1-4] established an evaluation index system based on the negative effects of physical geography, geology, hydrogeology and other influencing factors on karst groundwater environment, and used analytic hierarchy process to evaluate the level of negative effects of groundwater environment generated in tunnel construction. Li Liping et al. [5] obtained the relationship between factors affecting water gushing and occurrence probability and frequency through statistical analysis of domestic karst tunnel water gushing projects in recent 50 years, so as to determine the weight and establish a fuzzy hierarchical evaluation model. Li Zhilin et al. [6] selected the factors of karst water inrush by fuzzy evaluation model and determined the weights by artificial neural network wavelet analysis, so as to assess the risk of karst tunnel. However, they did not consider the influence of karst caves and backfills on the safety evaluation of groundwater in

1 [1]Zhejiang College of Security Technology Wenzhou 325016, Zhejiang, China. Email:sha_safety@163.com

[2]School of Environment and Resource, Southwest University of Science and Technology,Mianyang 621010,Sichuan,China

super-large gallery backfill karst tunnels. Wang Zigao [7] obtained physical and mechanical property parameters of accumulation bodies in the study of accumulation engineering, and proposed quantitative indexes for engineering geological evaluation. Zhao Jianqing et al. [8] summarized the experimental results of the rockfill and obtained the factors affecting the compression deformation of the rockfill. According to Sun Wei' s laboratory test analysis [9], the backfill with good gravel grading and good compactness has high shear strength, and the quality of backfill is evaluated by Rayleigh wave velocity, resilience modulus and compactness. Xu Guoding et al.[10] measured the relationship between soil permeability coefficient and soil compactness. Liu Yingjing[11] et al. determined the influence of particle-level pairing on drainage mechanical properties through research. Ge Zhexheng et al. [12] evaluated the properties and effects of various backfill materials on the back of the platform. However, their research results have not been applied to the safety evaluation of groundwater in super-large gallery backfill karst tunnels. Zhang Yongjie[13] et al. used fuzzy theory to evaluate tunnel caves. Zhao Minghua et al.[14] studied the negative friction resistance method of pile side for soft soil foundation.

On the basis of physical geography, geology, hydrogeology and tunnel engineering, a new evaluation index system is proposed, and the weight of each index is determined by combining BP neural network and AHP to establish a fuzzy evaluation model of groundwater safety in backfill karst tunnel. This paper studies the engineering problem of groundwater safety assessment in large gallery backfill karst tunnel.

1 Assessment Indicator System

1.1 Criterion Layer

The evaluation of groundwater safety in super-large gallery backfill karst tunnels heavily depends on criteria related to backfill quality and the presence of karst tunnels. Therefore, a set of new criteria layer is established on the basis of considering the physical geography, geology, hydrogeology and tunnel engineering criteria outside the karst tunnel. As shown in Figure 1.

1.2 Evaluation Index and Standard

The groundwater safety indexes and evaluation criteria corresponding to the five criterion layers of physical geography outside the karst cave are shown in Table 1-Table 5.

This paper starts from the safety of underground water in the super-large gallery backfill karst tunnel, and tries to cover the related factors as far as possible, so as to achieve the purpose of scientific evaluation of underground water safety in the super-large gallery backfill karst tunnel.

2 Evaluation Methodology

Utilizing the evaluation index system, this study employs a fuzzy comprehensive evaluation method integrating AHP and BP neural network to ascertain weights. Figure 2 illustrates the development of the fuzzy comprehensive evaluation model for assessing groundwater safety in super-large gallery backfill karst tunnels and determining relevant parameters.

2.1 The Determination of the Factor Set (index system) of Comprehensive Evaluation

（1）Based on the features of karst tunnels and input from experts, a comprehensive set of evaluation factors (index system) has been devised.

（2）Groundwater can be divided into different grades in the comprehensive evaluation. The rating of the review set is 1,3,5,7,9 points, so the review set is represented as: $D = \{1,3,5,7,9\text{points}\}$

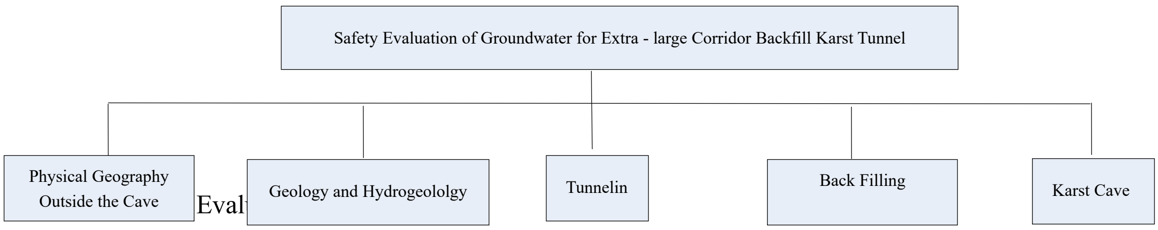
2.2 To Determine that Each Index B_i Belongs to the Membership Degree r_{ij} of the Comments in D

If the number of judges is set as n, then the membership degree of a certain index in the tunnel groundwater safety index layer belonging to a certain comment in v is expressed as:

$$rij = \frac{a\ factor\ in\ the\ index\ layer, the\ number\ of\ Bij\ judges\ rated\ it\ as\ the\ Jth\ level\ in\ D}{n}$$

Since the index layer is divided into five categories according to the criterion layer, the evaluation set matrix is constructed by taking the elements in each category as a whole. Since the evaluation set is divided into 5 levels, a matrix is defined for each criterion layer. For example, the physical geography class matrix is R_1 of 5*5, and the other criterion layers can be obtained R_2, R_3, R_4, R_5 and so on.

$$R_1 = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} \end{bmatrix}$$



3 Weight Determination and Comprehensive Evaluation

To emphasize the significance of each index in the evaluation, weights were assigned to determine the final evaluation results. Current methods for determining weights include AHP, Delphi method, expert scoring method, entropy weight method, standard deviation method, and CRITIC method, among others. This study integrates AHP with BP neural network training to establish the weight.

3.1 The Analytic Hierarchy Process Determines the Weights

The comparison matrix is formed by pairwise comparison of factors. Each time, two factors x_i and x_j are taken, and a_{ij} is used to represent the ratio of the influence size of x_i and x_j on the criterion layer. All comparison results are represented by matrix $A=(a_{ij})_{n\times n}$, and A is the contrast judgment matrix between the criterion layer and the index layer. For the determined values, saaty's recommended reference number 1-9 machine reciprocal is used as the scale. Table 6 lists the meanings of scales 1 to 9.

By judging the eigenvector W of the maximum eigenvalue $\lambda_{\max}$ corresponding to matrix A, we can get the ranking weight of the relative importance of the corresponding element of the same level to an element of the previous level after normalization. While constructing the judgment matrix helps minimize interference from other factors and objectively reflects differences in each factor's influence, synthesizing all comparison results may introduce some degree of inconsistency. Therefore, it is necessary to assess the consistency of the judgment matrix. The steps for checking the consistency of the judgment matrix are outlined as follows:

（1）Calculate the consistency Index CI.

（2）Find the corresponding average random consistency index RI. Table 7 shows the corresponding RI values of each value.

Table 7 Values for Each Value Corresponding to the Value of RI

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

（3）Calculate the consistency ratio CR

$$CR=\frac{CI}{RI}$$

When CR<0.10, it is considered that the consistency of the judgment matrix is acceptable, otherwise the judgment matrix should be appropriately modified.

3.2 BP Neural Network Method

（1）Network construction

The BP neural network consists of an input layer, a hidden layer, and an output layer. Each review set in this study serves as a training sample for the neural network. There are n training samples, with each sample containing m training indicators (represented by m nodes in the input layer).The initial evaluation set matrix K_{nm} is formed, and K_{nm} is used as the input vector; The hidden layer contains k nodes whose output vector is Y; The output layer contains t nodes whose output vector is U. In the connection weight matrix $V=(v_{ij})_{m\times k}$, v_{ij} from the input layer to the hidden layer represents the connection weight between the I-th node of the input layer and the J-th node of the hidden layer; In he connection weight between the hidden layer and the output layer $W=(w_{jz})_{kt}$, w_{jk} indicates the connection weight between the J-th node of the hidden layer and the z-th node of the output layer, as shown in figure 3.

（2）Calculate each output layer

Output Y for the hidden layer:

$$y_j = f(\sum_{i=1}^{m} v_{ij} x_i) \qquad j = 1,2,\ldots\ldots,k$$

Output U for the hidden layer:

$$u_z = f(\sum_{j=1}^{k} w_{jz} y_j) \qquad z = 1,2,\ldots\ldots,t$$

During BP neural network training, the activation function chosen for the transfer from the input layer to the hidden layer and from the hidden layer to the output layer is the log-S-shaped function:

$$f(x) = \frac{1}{1+e^{-x}} \qquad (0 < f(x) < 1)。$$

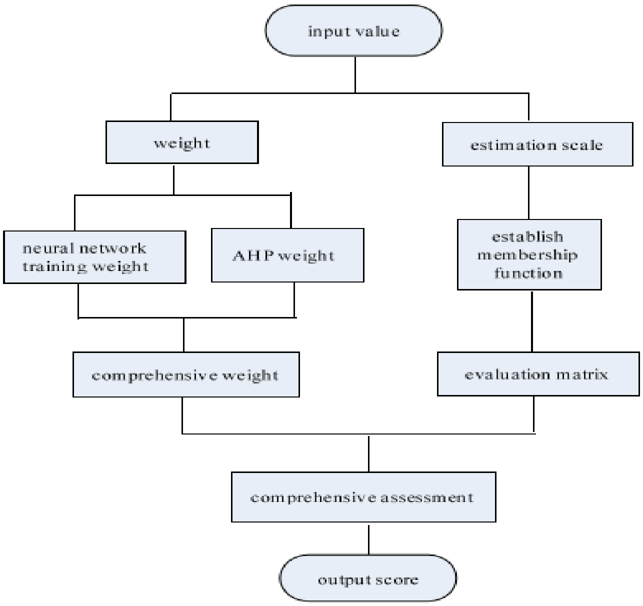


Fig. 2 Evaluation Method Flow Chart

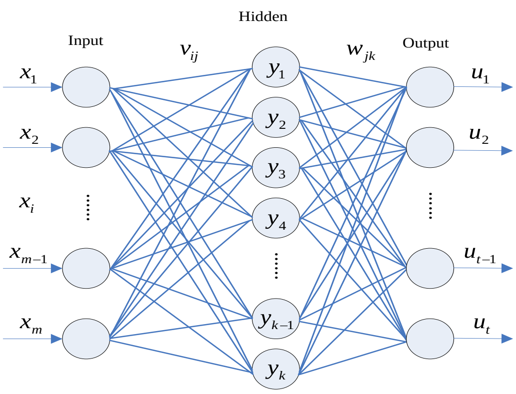


Fig. 3 Neural network model

（3）Network training

The connection weights V and W of each layer are initialized with small random values for each element. Each index data from the sample serves as the input data for the nodes in the input layer. The training procedure unfolds as follows.

① Network error calculation

During the network training process, there is a presence of network error. When the network output does not match the expected output, the output error E is defined as follows:

$$E=\frac{1}{2}\sum_{i=1}^{n}E_i$$

$$E_i=\frac{1}{2(d_i-u_i)}$$

② Weight adjustment

The error obtained from the expected output d of the output layer is δ_k^u compared with the actual output, and the weight between the hidden layer and the output layer is adjusted. Error δ_k^u is reversely transmitted to the hidden layer to obtain error δ_j^y of the hidden layer, thus adjusting the weight between the input layer and the hidden layer. The formula in the calculation process is as follows:

$$\delta_k^u=(d-u_k)u_k(1-u_k)$$

$$\delta_j^y=\delta_k^u z_j y_j(1-y_j)$$

$$w_{jz}(t)=w_{jz}(t-1)+\eta\delta^u y_{jz}+\mu\Delta z_{jz}(t-1)$$

$$v_{ij}(t)=v_{ij}(t-1)+\eta\delta^o x_{ij}+\mu\Delta v_{ij}(t-1)$$

$\eta\in(0,1)$ is learning rate; $\eta\in(0,1)$ is the momentum term, which reflects the accumulated adjustment experience, can accelerate the convergence of the network and improve the training speed of the network.

③ After the sample training, if E< $E_{\min}$ ($E_{\min}$ is the network training precision, set as a positive decimal), the training ends; Otherwise, you need to return to step 1 and retrain the network.

④ Enter the training index sample of the next criterion layer and return to step 1 for network training.

（4）Calculated weight

After the index sample training of all criterion layers meets the network accuracy requirements, the training is finished. Since the weight between the input layer and the hidden layer is $V=(v_{ij})_{m\times k}$, the absolute sum of the weight between the input node and all the hidden layer nodes is calculated, and the weight of each index in each criterion layer is obtained through normalization operation. Its calculation formula is as follows:

$$v_i = \frac{\sum_{j=1}^{k} |v_{ij}|}{\sum_{i=1}^{m}\sum_{j=1}^{k} |v_{ij}|} \quad i = 1,2,3,\dots,m$$

According to the method combined with the above expert scoring method and the BP neural network training weight 50/50, the weight vector is determined as follows:

$$A = (a_1, a_2, a_3, a_4, a_5)$$

$$A_1 = (a_{11}, a_{12}, a_{13}, a_{14}, a_{15})$$

$$A_2 = (a_{21}, a_{22}, a_{23}, a_{24}, a_{25}, a_{26}, a_{27}, a_{28}, a_{29})$$

$$A_3 = (a_{31}, a_{32}, a_{33}, a_{34}, a_{35}, a_{36})$$

$$A_4 = (a_{41}, a_{42}, a_{43}, a_{44}, a_{45}, a_{46}, a_{47}, a_{48}, a_{49}, a_{410}, a_{411}) \quad A_5 = (a_{51}, a_{52}, a_{53}, a_{54}, a_{55}, a_{56})$$

Table 1 Physical Geography Evaluation Index and Standard

Index	Weak1	Relatively Weak3	Medium 5	Strong7	Fairly Strong9
surface catchment area b11km2	>80	40-80	20-40	10-20	<10
the average annual rainfall is b12mm	>1600	1000-1600	800-100 0	600-800	<600
annual average evaporation b13mm	<400	400-500	500-600	600-800	>800
crepitation infiltration coefficient b14	>0.50	0.30-0.50	0.15-0.3 0	0.05-0.15	<0.05
relationship between tunnels and landforms b15	parallel pattern below the valley	transversal river type	valley parallel	single e bevel cut	other (e.g. flat, convex)

Table 2 Geological, Hydrogeological Evaluation Indicators and Standards

Index	Weak1	Relatively weak3	Medium5	Strong7	Fairly Strong9
formation lithology b_{21}	karst	weathered metamorphic rock	weathered granite	sandstone	mudstone, shale, etc
fault b_{22}	little	menos Less	general	relatively much more	much
groundwater supplement and diameter condition b_{23}	discharge area	heavy runoff area	weak runoff area	Weak recharge area	recharge area

soluble rock exposure ratio (%)b_{24}	>90	70-90	50-70	30-50	<30
fracture zone development degree b_{25}	developmental	more developed	general	less developed	rudimentary
karst groundwater depth b_{26}	<5	10-5	30-10	50-30	>50
Rock strata are water-rich b_{27}	rich water,	water	medium water,	little water	no water
fold b28	fault-developed folds	fold fissures	developmental fissure	pleated	creaseless
groundwater chemical type b_{29}	Cl	SO4-Cl	SO4	HCO3-SO4	HCO3

Table 3 Evaluation Index and Standard for Tunnel Engineering

Index	Weak1	Relatively Weak3	Medium5	Strong7	Fairly Strong9
depth of tunnel b31	>1000	500-1000	300-500	100-300	<100
tunnel influence rangeb32	>3	2-3	1-2	0.4-1	<0.4
length of tunnel(km) b33	>30.0	10.0-30.0	3.0-10.0	1.0-3.0	<1.0
excavated section area(m2)b34	>350	250-350	120-250	50-120	<50
the discharge rate of tunnel gushing(m3/d)b35	>100000	10000-100000	1000-10000	100-1000	<100
construction method b36	the whole section explosion method	setback-type method	partial excavation	NATM	TBM

Table 4 Backfill Evaluation Indicators and Standards

Indicators	Weak1	Relatively weak3	Medium5	Strong7	Fairly Strong9
the modulus of rebound (Mpa) was b41	>100	85-100	70-85	55-70	<55
B42 backfilling body compaction (%)	>97	96≤-97	95≤-96	93≤-95	<93
rayleigh wave velocity (m/s)b43	>500	310-500	250-310	140-250	<140
backfill aggregate particle grade b44	good	Slightly good	medium	Slightly bad	bad

backfill material b45	backfill of mortar bricks	gravel backfill	gravel soil backfill	eolian sand backfill	lime soil backfill
the backfill body permeability coefficient b46	>0.50	0.30-0.50	0.15-0.30	0.05-0.15	<0.05

Table 5 Karst Evaluation Indicators and Standards

Index	Weak1	Relatively Weak3	Medium5	Strong7	Fairly Strong9
the water capacity of the cave b51	much	more	generally	little	less
cave size b52	giant Rock Hall	rock hall	Oiwaya	Iwaya	channel
cave water source b53	rivers and lakes	underground river water	surface spring	surface catchment	atmospheric precipitation
weathering condition of cave b54	full weathering	strong weathering	ilmd weathering	aeration	unweathered
drainage mode b55	drainage well	drain basin	drain	drainage pipe	not process
chemical type of cave water b56	Cl type	SO4-Cl type	SO4 type	HCO3-SO4 type	HCO3 type

Table 6 The Meaning of Each Scale

Scale	Implication
1	Both factors are of equal importance in comparison
3	The former is slightly more important than the latter
5	The former is significantly more important than the latter
7	The former is more important than the latter
9	The former is more important than the latter
reciprocal	The ratio of the importance of factor i to factor j is a_{ij}, and the ratio of the importance of factor j to factor i is its reciprocal $a_{ji} = 1/a_{ij}$

3.3 Comprehensive Evaluation of Negative Effects on Groundwater Environment of Tunnel Karst Cave

$$B = AOR = (a_1, a_2, a_3, a_4, a_5)O\begin{pmatrix} A_1OR_1 \\ A_2OR_2 \\ A_3OR_3 \\ A_4OR_4 \\ A_5OR_5 \end{pmatrix}$$

$$= (a_1, a_2, a_3)O\begin{pmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{pmatrix}$$

$$= (b_1, b_2, b_3, b_4, b_5)$$

The normalization of B results in:

$$B = \left(\frac{b_1}{\sum_{i=1}^{5} b_i}, \frac{b_2}{\sum_{i=1}^{5} b_i}, \frac{b_3}{\sum_{i=1}^{5} b_i}, \ldots\ldots, \frac{b_5}{\sum_{i=1}^{5} b_i}\right) = (C_1\%, C_2\%, C_3\%, C_4\%, C_5\%)$$

The results show that for the negative effect of water environment, $C_2\%$ people think that it can score 1 point, $C_3\%$ people think that it can score 3 points, $C_5\%$ people think that it can score 5 points, $C_4\%$ people think it can score 7 points, $C_5\%$ people think it can score 9 points.

Further, 1, 3, 5, 7 and 9 points are divided into 5 grades. $Y = (1,3,5,7,9)^T$, so the comprehensive evaluation of the negative effect of water environment is divided into: $Z = BOY$

$$Z = 1C_1\% + 3C_2\% + 5C_3\% + 7C_4\% + 9C_5\%$$

4 Engineering Application

4.1 Project Profile

The annual average rainfall is 1410.5mm, generally 1300.1~1649.7mm, the annual maximum rainfall is 2011.15mm, the annual minimum rainfall is 952.1mm, the annual average evaporation is 1143.3mm, generally 1015.2~1259.3mm. The tunnel is basically east-west, the bad geology is karst, and the karst form is dominated by vertical karst collapse. There are four large karst collapse pits in the exit section of the tunnel. The No. 3 karst collapse pit is developed at 20m left of K14+360, and the No. 4 karst collapse pit is developed at 100m left of K14+600. The hall karst cave is basically located below the No. 3 and No. 4 pits.

The tunnel area lacks a distinct surface water system, predominantly containing pore water and karst groundwater types. This condition prevents the formation of a stable groundwater surface and minimizes its impact on the tunnel; Karst water mainly exists in karst fractures and karst pipes of limestone, and the buried depth of the stable groundwater level is lower than the tunnel floor, which is difficult to have a great adverse effect on the tunnel. The surrounding rock of the tunnel is composed of breezy limestone, which has a medium and thick layered structure, and its failure form is mainly falling block. In the local karst development zone, the surrounding rock stability is compromised, with potential for minor collapses, and groundwater exerts a noticeable influence.

The groundwater in the tunnel area seeps through fissures in limestone. Its limited volume minimally affects the tunnel, occasionally manifesting as dripping or localized rainfall-like conditions during excavation. There is no pollution source of water quality in the tunnel area and its vicinity, and the surface and groundwater in the tunnel area are not corrosive to the concrete structure. The water inflow in the tunnel is about 6,000. m^3/d . When it is not raining, there is no surface water in the mountain gullies through which the tunnel passes. Karst groundwater is fed by atmospheric precipitation. Affected by topography, the atmospheric precipitation is dispersed into the collapse pit, so the catchment area of a single collapse pit is small. According to the survey report, the infiltration coefficient method of atmospheric precipitation is used to find that the average water content of the cave is 189 m^3/d . There is basically no groundwater in the cave when it does not rain normally, and the amount of water inflow during rainstorm days may be tens of times of the average value. The drainage design of karst cave is to set up reinforced concrete drainage culvert, and the plane position of culvert is located at the center line of tunnel lining. PVC drainage pipes are arranged in two vertical and vertical rows for each culvert joint break. Three vertical drainage blind pipes are arranged to the arch culvert in the unfilled cavity where water accumulation is likely to occur.

The tunnel passes through the roof of the intact cave. The cave cavity is located at the lower left of the tunnel and does not invade the tunnel excavation contour. The karst shape of this section is complex, and it is difficult for construction machinery to enter, so the backfill of this section is mainly artificial, and all the cavities are backfilled tightly, without damaging the cave roof. The culvert perimeter is backfilled with dry masonry, 0.5m above the culvert top. The height is below 445m, backfill the grouting stone, and the irregular section under the roof of the karst cave above 445m is pumped through the main hole to fill with C20 concrete. The strength of stone filling subgrade should not be less than 15Mpa. The backfilling strength of hole slag is not less than 93%. The thickness of the paving layer is not more than 600mm, the maximum particle size is less than 2/3 of the thickness of the layer, the porosity is not more than 25%, and the lamination is compacted. A geotextile is arranged between the hole slag and the graded gravel backfill layer.

4.2 Safety Evaluation

Table 8-Table 13 lists the project weights based on 4.1

criterion layer	b_1	b_2	b_3	b_4	b_5
BP weight	0.3138	0.2001	0.227	0.1663	0.0928
expert weight	0.3449	0.4776	0.0711	0.0547	0.0517

Table 9 Physical Geography Evaluation Index Outside the Cave

Index	b_{11}	b_{12}	b_{13}	b_{14}	b_{15}
BP weight	0.1694	0.1832	0.2859	0.1693	0.1923
expert weight degree	0.0459	0.3584	0.1648	0.4027	0.0283

Table 10 Geological, Hydrogeological Evaluation Index Weight

Index	b_{21}	b_{22}	b_{23}	b_{24}	b_{25}	b_{26}	b_{27}	b_{28}	b_{29}

BP weight	0.1014	0.1012	0.107	0.0892	0.0468	0.1024	0.1916	0.1932	0.0673
expert weight degree	0.0171	0.1277	0.2903	0.0145	0.1752	0.0808	0.0702	0.2011	0.0232

Table 11 Tunnel Engineering Evaluation Index Weight

Index	b_{31}	b_{32}	b_{33}	b_{34}	b_{35}	b_{36}
BP weight	0.2478	0.0933	0.1295	0.1253	0.1808	0.2233
expert weight	0.031	0.0512	0.1213	0.1412	0.5335	0.1219

Table 12 Backfill Evaluation Index Eeight

Index	b_{41}	b_{42}	b_{43}	b_{44}	b_{45}	b_{46}
BP weight	0.1673	0.2748	0.1501	0.1269	0.1118	0.169
expert weight	0.0264	0.0757	0.444	0.3726	0.1355	0.3475

Table 13 Karst Evaluation Index Weight

Index	b_{51}	b_{52}	b_{53}	b_{54}	b_{55}	b_{56}
BP weight	0.232	0.183	0.135	0.211	0.061	0.179
expert weight	0.1015	0.0254	0.2206	0.0524	0.5651	0.35

$B = [0.0450, 0.1630, 0.2941, 0.3215, 0.1764]$

The results show that 4.5% of the experts think that the underground water safety evaluation of the super-large gallery backfill karst tunnel can be scored 1, 16.3%, 29.41%, 5, 32.15%, and 9, respectively. Therefore, the underground water safety evaluation score of this super large gallery backfill karst tunnel is as follows: Z=5.8426

5 Conclusion

Through in-depth research on the underground water safety evaluation method of the super-large gallery backfill karst tunnel, the following conclusions are reached：

（1）According to the natural characteristics of super large gallery type karst tunnel and the physical and mechanical properties of the backfill body, five criterion layers of physical geography, geology and hydrogeology, tunnel structure, backfill body characteristics and karst tunnel were put forward, and the evaluation index system of super large gallery type karst tunnel was established.

（2）Based on the weights determined by AHP and BP neural network and combined with fuzzy comprehensive evaluation method, a new method for groundwater safety evaluation of super-large gallery backfill karst tunnel is proposed. The rationality of the method is demonstrated by the analysis of engineering examples.

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ABOUT THE AUTHOR

Ce Sha was born in Wenzhou，Zhejiang. China, in 1992. He graduated from Central South University with a master's degree. His main research direction is Safety Science and Engineering, Tunnel Engineering and Metal Mines.

E-mail: sha_safety@163.com

Yaoyao Huang:

Zhejiang College of Security Technology Wenzhou 325016, Zhejiang, China.

E-mail: 371192064@qq.com

Yunlou Qian:

School of Environment and Resource, Southwest University of Science and Technology,Mianyang 621010,Sichuan,China.

E-mail:qianyun-lou@qq.com

Kaikai Jin:

Zhejiang College of Security Technology Wenzhou 325016, Zhejiang, China.

E-mail: 26364914@qq.com