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Analysis of determining the weights of risk assessment indexes for barracks facilities construction units in highland and alpine areas based on AHP hierarchical analysis method

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SUMMARY: *This research has constructed a risk assessment model which is used for camp facilities in high-altitude and alpine regions. This work carries out three stages: index starting establishment, choice checking, and modification to confirm the last risk evaluation indexes for the construction organization. After that, through utilizing the AHP (Analytic Hierarchy Process) method, a judgment matrix is established through pairwise comparison of indicators on all levels. This matrix may assist the work of confirming the weight values of the evaluation indicators. Next, we utilize the fuzzy quantification method to carry out the fuzzy overall evaluation on the risk that relates to the agent construction unit for barracks installations in high-altitude and frigid mountain zones.One risk evaluation framework was by us developed for building construction units of barracks in high-altitude cold regions. This framework is constituted of five first-order metrics and thirteen second-order metrics. Inside one specific case study, we used the Analytical Hierarchy Process (AHP) to carry out the calculation of the weights. The average value weights got by arithmetic method of natural risks, economic risks, environmental risks, management risks, and security risks are therefore determined as 0.085, 0.165, 0.276, 0.429, and 0.045 each one respectively. In addition, the comprehensive weight values of the second-level indicators have been discovered to lie in the scope of 0.023 to 0.175. The fuzzy rating of the risk of the substitute unit shows that the scores of the risk factors are mostly concentrated between 2 and 4, which are in the category of general risk and greater risk.*

KEYWORDS: *Risk evaluation model; AHP hierarchical analysis; fuzzy quantification; substitute construction unit; plateau alpine barracks*

1 Introduction

Plateau alpine region as an important border area, related to national security, its high altitude, the existence of various types of canyons, gullies, glaciers and permafrost makes the terrain terrain conditions are complex, and often presents a cold climate, low atmospheric pressure, thin air, ultraviolet rays, precipitation is small, wind and sand and dust, and other climatic characteristics, is a key element affecting the performance of the facilities in the region [1-5]. As an important infrastructure for the army and border guards in border areas, barracks provide basic protection for their life, combat, patrol, etc., and their facility performance and service life are related to personnel safety, regional environmental protection, and economic costs [6]. Chen et al [7] tested the microstructural changes of concrete surfaces in the complex climate of the plateau, therefore, the mechanical performance and long-term living ability of concrete surfaces that are exposed to the atmosphere have a decline, and moisture absorption was even

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lower, reducing the service life of the material. Wang et al [8] pointed out that the temperature stresses on the sides of concrete increase with the increase of wind speed and temperature difference under the temperature difference in cold regions, and the drastic changes in the temperature stresses of concrete can affect the structural stability and durability. Qiu and his [9]work group carried out evaluation that the load-bearing ability of the single-pile base of one building has a drop in the thawing period of long-term permafrost, and the frost resistance of the pile-soil interface will be reduced, and with the increase of the permafrost temperature at the end of the pile, the settlement rate of the pile will be accelerated. Wang and his working group have comprehensively elaborated the characteristics of accelerated aging that polyvinyl chloride microplastics possess. They put very great emphasis on the quickened aging course of these materials when they are exposed to ultraviolet radiation,of which polyvinyl chloride is one of the main materials used in tarpaulins for barracks facilities. It can be seen that the climate and topographic terrain of the highland alpine region seriously increase the risk of barracks construction. Therefore, as a key main body in the construction of barracks infrastructure, the organization must assess the multi-sided risks which include the natural environment, economic elements, technological parts, management situations, and other aspects that exist at the site where barracks are built. This evaluation has been conducted by us in order to ensure the stable and safe situation of the barracks facilities' construction work.

Risk assessment is mainly a comprehensive and integrated analysis of the risks existing in the project, and according to the degree of impact of the risks, the risk level ranking. At the same time, under the premise of project risk identification, project risks and their influencing factors and other factors are analyzed through the project risk evaluation index system, so as to calculate the probability of occurrence of each risk and the project loss that will be caused by the risk, and then through the comparison, to grasp the core risk in the project, and to determine the overall risk in the project [11-14]. Analytic Hierarchy Process, namely AHP, is a method which appeared in the 1980s, and it has obtained widespread use in risk assessment work. This level-by-level analysis method was put forward in that time period and has hence become a commonly employed instrument for assessing risks. This method is able to provide a comprehensive risk evaluation of different scenarios, factors, and criteria, as well as an efficient prediction of trends [15-17]. Yue [18]and his work group made use of entropy weights and fuzzy numbers for the enhancing of the Analytic [19]Hierarchy Process (AHP) method. They afterwards developed this strengthened method to assess the risk weight computation in the building course of highway bridges in the mountain areas of the plateau. After that, they have successfully finished the classification of the construction risk kinds. At the same time, Eskander and other persons utilized the AHP method for measuring the weight values of assorted risk factors in the comparison of construction uncertainty risk parameters of construction items. This step was conducted for the purpose of standardizing, ranking the project risks and hence finally determining the priority of project risks. Gamal et al [20] proposed a solid risk management optimization framework for construction project building based on AHP methodology, which was achieved through identification and prioritization based on weighting calculator, covering the risks of cost, schedule and quality.AHP effectively combines the quantitative and qualitative aspects and solves the problems in both of them, so as to quantify the decision maker's judgment, and to provide support for Determining the weights of risk assessment indexes for barracks facility generation units in plateau alpine areas provides support.

This article establishes a risk evaluation index system for a barracks building construction main body in the high-altitude mountain region. Afterwards, this system is put into use for the risk evaluation of a barracks facility construction body that sits in the high-altitude area of the Qinghai-Tibet Plateau.Based on the data which we got from interviews with many related experts, the Analytic Hierarchy Process (AHP), which is a method for layered analysis, is used by us. Firstly, through the establishment of a judgment matrix and the carrying out of a consistency check, the assignment outcomes of each index that experts have given in the risk evaluation of the construction unit are step by step determined. At last, through the combination of the fuzzy comprehensive evaluation method, the risk grade of the organization construction unit in this project is got.

2 Risk assessment methodology for the agency

The core risk assessment method used in this paper is mainly AHP hierarchical analysis and fuzzy quantitative method, in which relevant experts determine the evaluation indexes, the method of Analytic Hierarchy Process (AHP) is utilized by us for the ascertainment of the weight of every index. After that, the fuzzy quantity method is employed by us to set up the risk grade.

2.1 AHP Hierarchical Analysis

AHP is a systematic method based on qualitative and quantitative analysis proposed by American operations researcher Satie in the 1970s. This method can divide multiple elements in a decision-making problem into three levels of objectives, criteria and indices to make it more organized, and quantitatively describe the elements of the same level through qualitative judgments. The individual who carries out decision-making possesses the choice to utilize mathematical methods to calculate the numerical figures that stand for the weightings of the components on each level. Through this method, therefore, one can be enabled to infer the importance ordering of the factors which are in every level, and then make a comprehensive evaluation of the problem under study based on the weights of the indices. In this study, the index system for evaluating the dangers of the camp facility replace unit in high-height alpine areas is established through the utilization of AHP (Analytic Hierarchy Process) layer analysis. The 1 - 9 grade method of AHP is utilized to carry out one-to-one comparisons among elements which are at the same level and those that are from the prior level. The detailed procedures for conducting AHP hierarchical analysis are just as below:

(1) Classification of recursive layered structure framework. According to the connection between components of every level, the layered structure built by the AHP hierarchical analysis method is generally divided into three kinds:

a. completely relevant structure exists, hence there is a fully relevant link between the components of upper and lower levels.

b. A complete self-governing construction in which no connection exists between the parts of the upper and lower layers, and no connection is there.

c. Hybrid structure, which is a mixture of the above two structures, where there are both correlated and non-correlated elements between the elements of the two layers, both a structure that is neither completely correlated nor completely independent.

(2) Carry out the construction of a recursive hierarchical framework model. According to the rules of building and the convenience of calculation, the model is usually divided into three layers:

a. Goal level: the highest level, is the project decision maker according to the project objectives of the standard.

b. Criteria layer: is the constraint level of the above levels, mainly used to judge the role of the program's advantages and disadvantages.

c. Program level: also known as the response level, refers to the feasible solution to the decision-making problem.

Figure 1 has described the level-type frame of the risk evaluation which is for the construction main body.

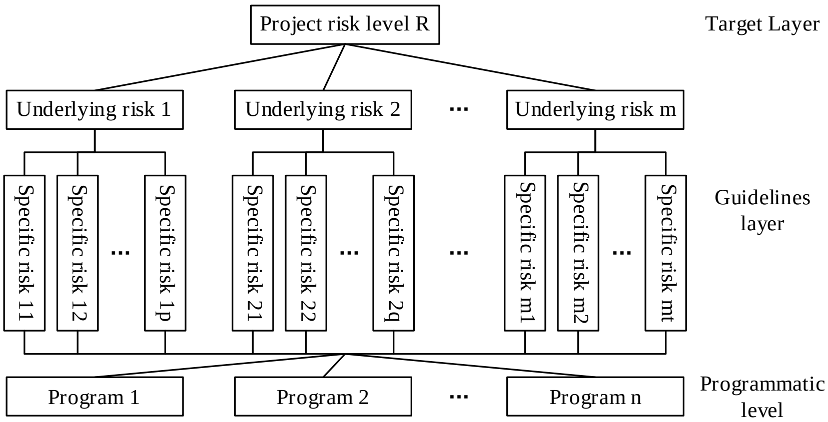

Figure 1 gives a principle explanation of the level structure for risk evaluation.

(3) Use the two-by-two comparison method to construct all judgment matrices

Since each indicator factor at the same level has a different degree of influence on the upper level objectives, i.e., the importance weight coefficients are different, the experts are asked to compare the influencing factors at each level two by two to build the judgment matrix. The judgment matrix is shown in Table 1.

Table 1: Judgment matrix table

B	B_1	B_2	$\cdots$	B_m
B_1	B_{11}	B_{12}	$\cdots$	B_{1m}
B_2	B_{21}	B_{22}	$\cdots$	B_{2m}
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
B_m	B_{m1}	B_{m2}	$\cdots$	B_{mm}

In the table, b_{ij} denotes the importance scale of the risk factor i compared to the risk factor j with respect to B. $0 < b_{ij} \le 9, b_{ii} = 1, b_{ji} = \frac{1}{b_{ij}}$, i.e., B is a positive inverse matrix. The scale is defined as follows:

Scale 1: When we carry out evaluation on the two elements, it is able to be determined that they possess equal importance in the connection with each other.

Scale 3: When we carry out a comparison of the two elements, it can be seen clearly that the former element holds a tiny superiority on the aspect of importance when compared with the latter.

Level 5: From the perspective of importance, the previous component far exceeds the latter one.

Scale 7: After we make comparison between these two elements, we can see that the front one is much more important than the back one.

Scale 9: When we carry out a comparison of the two elements, the former has much bigger importance than the latter.

Scale 2, 4, 6, 8: These stand for the middle numerical values of the above-mentioned neighbor judgments.

Inversion: When two elements carry out contrast, the importance of the second element exceeds that of the first.

(4) Confirm the importance of each index with regard to the higher-level index that it belongs to.

According to the principle of scaling, the judgment matrix has been constructed by us. The step for calculating the weight w_i of one index in a layer regarding the upper-level layer which it belongs to may be described as follows:

$$w_i^o = \left(\prod_{j=1}^{m} b_{ij}\right)^{\frac{1}{m}} \quad (1)$$

$$w_i' = \frac{w_i^o}{\sum_i w_i^o} \quad (2)$$

(5) Calculate the maximum eigenvalue of the judgment matrix λ_{max} and $C.R$ for consistency test

The consistency test of judgment matrix can be determined by the consistency index C.R. When $C.R. < 0.1$, the judgment matrix conforms to the consistency test. When $C.R. > 0.1$, the judgment matrix needs to be adjusted so that it meets the consistency test requirements. $C.R.$ is determined by the following formula:

$$\lambda \max = \frac{1}{m}\sum_{i=1}^{m}\lambda_{mi} = \frac{1}{m}\sum_{i=1}^{m}\frac{\sum_{j=1}^{m} b_{ij} w_i^o}{w_i^o} \quad (3)$$

$$C.I. = \frac{\lambda_{\max} - m}{m-1} \quad (4)$$

$$C.R. = \frac{CI}{RI} \quad (5)$$

where $\lambda_{\max}$ is the maximum characteristic root of the judgment matrix, m the order of this matrix is given notation, that is R. I. This thing stands for the correction factor, that is called by people the average stochastic consistency index. The numerical values of the mean random consistency are exhibited in Table 2.

Table 2: Average consistency indicator

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49	1.52

(6) Ascertain the accumulated weight values of the underlying hazard elements inside the risk evaluation frame structure

(7) Carry out an all-round danger evaluation for each single program.

2.2 Fuzzy quantization methods

The main idea of the fuzzy quantitative approach is to:

a. A summarization is conducted of the main risk elements that influence the achievement of project objectives. The aggregate of standards which is employed for judging the possibility of their happening includes [substantial, high, medium, slight, extremely slight].

b. The rubrics can be specifically defined as numerical values so that they can be quantified when evaluated.

c. Define the matrix by determining the fuzzy evaluation method suitable for the study through questionnaires and empirical estimation.

c. Invite experts to give rubrics on the likelihood of occurrence of each risk factor and its consequences, utilizing Eq:

$$A_i = \left(\frac{1}{n}\right) \otimes \left(E_{i1} \otimes E_{i2} \ldots E_{in}\right) \tag{6}$$

where E_{ij} denotes the jth expert's comment on risk event i and A_i denotes the fuzzy value of event i.

This is converted into fuzzy possibility (P') and fuzzy consequence (S').

e. Apply fuzzy reasoning to determine the measure R of the risk factor with the following formula:

$$R = \left(P' \circ R(p)\right) \cap \left(C' \circ R(c)\right) \tag{7}$$

where "$\circ$" means that if A, B are two fuzzy subsets of x and y, then "$A \circ B$" has the following relation:

$$\mu_R(x, y) = \min\left[\mu_A(x), \mu_B(y)\right) \tag{8}$$

"$\cap$" denotes the fuzzy intersection operator, according to the above steps the size of the risk degree can be determined.

3 Modeling of indicators for evaluating the risk of construction of camps

3.1 Preliminary exploration of risk evaluation indicators for the construction agency

The constitution of indicators for the risk evaluation model of the agent construction main body is a key link of the construction of the risk evaluation model. The selected indicators should possess representativeness, being able to comprehensively and accurately reflect the potential risks which the agency construction subject could face.This research utilizes the AHP level analysis method to determine the weight values of the risk evaluation index items. Thereafter, it makes use of the fuzzy quantitative method to carry out the classification of the risk grade. Based on literature combing and expert consultation, this research from the angle of risk sources of the agency construction project, first establishes the index system for the risk evaluation model of the agency construction unit of barracks facilities in plateau alpine region.Table 3 shows the results that we get when we first set up the indicators for the risk evaluation model of the barracks facilities' organization construction unit in high-altitude and cold areas.

Table 3: The risk evaluation model index is preliminarian

Primary indicator	Number	Secondary indicator	Number
Natural risk	I1	Disaster risk (low temperature, permafrost, glacier, ultraviolet light, etc.)	I11
		Climate risk (blizzard, typhoon, etc.)	I12
Economic risk	I2	Exchange rate	I21
		Loan rate	I22
		Macroeconomic policy	I23
		Change of labor, raw materials and equipment	I24
		Price or total price error	I25
		The claim clause is unclear or missing	I26
		Error or omission of the quantity of quantities	I27
Environmental risk	I3	Ecological destruction	I31
		Uncertain hydrogeological conditions	I32
		Pollution, waste treatment	I33
		The influence of ethnic interests and local customs	I34
		Impact of public inquiry	I35
		Relevant construction regulations and regulations	I36
		The laws and regulations are not perfect	I37
		Construction approval procedure changes	I38
Management risk	I4	Moral hazard	I41
		Information deletion risk	I42
		Managerial ability risk	I43
		Cross management risk	I44
Safety risk	I5	Personnel safety risk	I51
		Equipment safety risk	I52

3.2 Secondary screening of risk evaluation indicators

In this research paper, the first turn of screening for evaluation indicators is completed through designing a Likert scale. After that, specialists in the field related to the reconstruction project of barracks buildings in high altitude and frigid zones are invited to score the risk assessment indexes shown in the above-mentioned table.We have carried out the dissemination of a survey questionnaire among 10 special experts. Inside this group, 3 pieces came from the owner's side, 3 pieces came from the replacement construction party, 1 piece came from the contractor, 1 piece came from the design unit, 1 piece came from the supervision group, and 1 piece came from the material and equipment supplier. The different background situations of these specialist persons were purposely chosen in order to ensure the scientific correctness of the grading results.The importance of indicators is classified as "very important", "very important", "important", "average" and "not important", represented by 5, 4, 3, 2 and 1 respectively. The larger the value, the more important the indicator, the greater the likelihood of the risk occurring or the more serious the consequences of the risk.

The expert appraisals of every index are shown in Figure 2, and Table 4 exhibits the descriptive statistic results of the marks for every single index.According to the statistical results of expert scoring, the indicators with average scores less than 3 are firstly removed. 4 evaluation indicators in the above table, namely, foreign exchange rate (I21), macroeconomic policy (I23), minority interests and local customs (I34), and changes in regulations and norms related to construction and building (I36) have average scores between 2.2 and 2.8, and are therefore firstly removed. In addition, loan interest rates (I22), errors in unit or lump sum prices of works (I25), errors or omissions in bill of quantities (I27), uncertain water quality conditions (I32), pollution and waste treatment (I33), impact of public questioning (I35), changes in the construction approval process (I38), risk of lack of information (I42), risk of managerial competence (I43), and risk of cross-management (I44) The mean value of the scores of the 10 evaluation indicators is greater than or equal to 3, but the standard deviation is greater than 1, indicating that the experts are more divided on the indicator. At this point in the study, this paper uses the Delphi method to determine whether the above 10 indicators can pass the screening. First, the 10 indicators to be determined are distributed to 10 scoring experts, who are asked to give scores and corresponding reasons. The expert questionnaire is collected, and the expert scores and reasons for each indicator are counted and organized, and then returned to the experts, who are asked to give scores and corresponding reasons for the indicators again. Repeat the above procedure until the standard deviation of the experts' scores on the indicators is less than or equal to 1. According to the results of the Delphi method, only the loan interest rate (I22), changes in construction approval procedures (I38), lack of information risk (I42), and management capacity risk (I43) of the above 10 indicators to be determined have a final score with a mean value greater than 3, while the remaining 6 indicators fail to pass the screening of the indicator system.

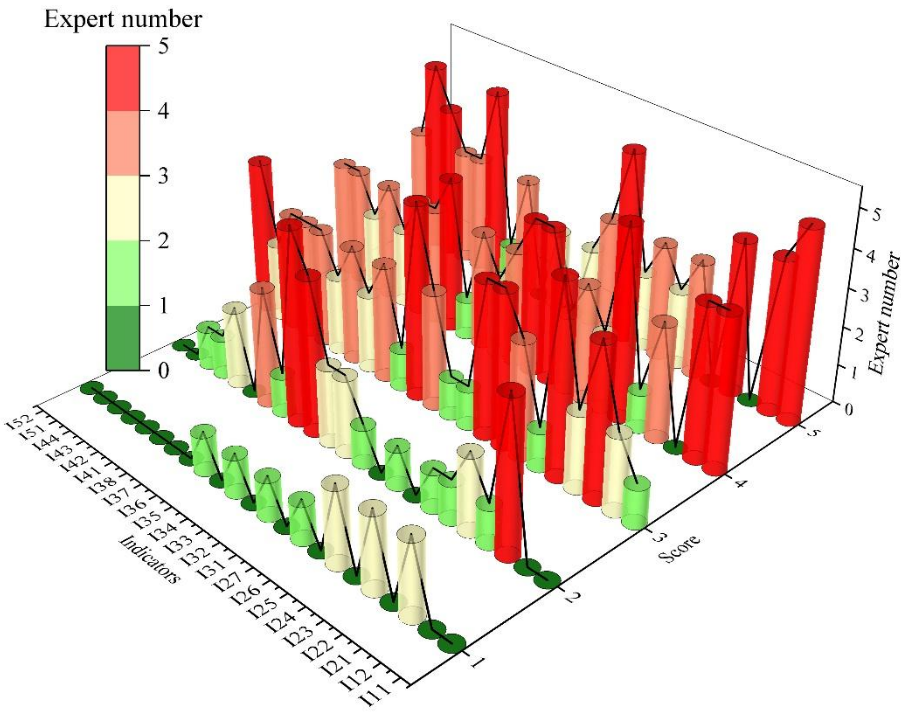

Figure 2: Each indicators expert scores the situation

Table 4: The indicators were annotated with descriptive statistics

Secondary indicator	Expert number						
	5	4	3	2	1	Ave	SD
I11	5	4	1	0	0	4.4	0.699
I12	4	4	2	0	0	4.2	0.789
I21	0	0	4	4	2	2.2	0.789
I22	4	3	2	1	0	4	1.054
I23	0	1	5	2	2	2.5	0.972
I24	3	5	1	1	0	4	0.943
I25	2	2	3	1	2	3.1	1.449
I26	3	3	4	0	0	3.9	0.876
I27	2	2	4	1	1	3.3	1.252
I31	5	4	1	0	0	4.4	0.699
I32	3	4	1	1	1	3.7	1.337
I33	2	3	3	2	0	3.5	1.080
I34	0	2	5	2	1	2.8	0.919
I35	2	3	1	4	0	3.3	1.252
I36	0	1	3	5	1	2.4	0.843
I37	3	4	2	1	0	3.9	0.994
I38	1	3	3	3	0	3.2	1.033
I41	5	3	2	0	0	4.3	0.823
I42	3	2	3	2	0	3.6	1.174
I43	3	3	3	1	0	3.8	1.033
I44	4	2	3	1	0	3.9	1.101
I51	5	3	2	0	0	4.3	0.823
I52	3	3	4	0	0	3.9	0.876

3.3 Adjustment and determination of evaluation indicators

This research has utilized expert marking and the Delphi method to carry out screening work on the preliminary indices of the risk evaluation model.In the course of the interviews with the experts, the experts suggested adjustments to some of the evaluation indicators. The names of individual indicators were modified for the sake of standardization and brevity of presentation. Experts suggest that "disaster risks (low temperatures, permafrost, glaciers, ultraviolet lamps)" be revised to "natural disasters", "climate risks (heavy snow, typhoons, etc.)" be revised to "severe weather", and "rising costs of labor, raw materials, equipment, etc." be revised to "rising prices". After the first step confirmation, check, and careful adjustment of the risk evaluation model targets for the agent construction units, the risk evaluation target system for the agent construction units of barracks buildings in high-altitude cold areas was finally built, which is shown in Table 5.

Table 5: The system of risk evaluation index system for construction units

Primary indicator	Number	Secondary indicator	Number
Natural risk	I1	Natural disaster	I11
		Bad weather	I12
Economic risk	I2	Loan rate	I21
		Price rise	I22
		The claim clause is unclear or missing	I23
Environmental risk	I3	Ecological destruction	I31
		The laws and regulations are not perfect	I32
		Construction approval procedure changes	I33
Management risk	I4	Moral hazard	I41
		Information deletion risk	I42
		Managerial ability risk	I43
Safety risk	I5	Personnel safety risk	I51
		Equipment safety risk	I52

4 Evaluation on dangers related to the institution's carrying out of camp place building in high-altitude and mountain areas

This research takes a barracks establishment organ situated in the high mountain region of the Tibetan Plateau as a case research. This project possesses a construction expenditure budget of three hundred million yuan, which is completely provided with funds. Its total construction scale is 250000 square meters, and it is composed of 160000 square meters of above-ground construction area and 90000 square meters of underground construction area.The work scope of the construction includes pile foundation building, foundation pit supporting, building building, interior fitting work, prefabricated building assembling, water feeding and draining systems, heat ventilating equipment, electric line laying, low-voltage electric systems, device setting up, and also all the preparation and pre-burying work for each specialized subject.

4.1 Determination of the weights of the risk evaluation indicators for the construction agency

By utilizing the risk assessment index model which was developed before for the barracks facilities producing unit in high-altitude alpine areas, a hierarchical single-ranking computation and the consistency check of it are carried out. Through the collection and analysis of original data coming from 15 investigation forms, the judgment matrix is constructed.For the purpose of acquiring two consistency indicating parameters, that is the Consistency Index (CI) and the Consistency Ratio (CR), the maximum characteristic value (λ max) and the characteristic vector (w) are calculated through computation. After that step, we make a judgment that whether the calculated CR is smaller than 0.1, therefore we evaluate whether the consistency test has been satisfied. When the test has the completion of passing, the weight values are by people regarded as having validity.

Taking the expert 1 data as an example of relevant calculations, we get the consistency judgment matrix of risk evaluation indexes of the barracks facility substitute unit in plateau alpine region as shown in Table 6. According to the expert 1 data, the natural risk (I1), economic risk (I2), environmental risk (I3), management risk (I4), the weight numerical values of the barracks facility generation unit's safety danger (I5) in the high cold region are 0.084, 0.177, 0.273, 0.425, and 0.042, respectively, and the eigenvalues of λ max = 5.14 and CI = 0.0344, CR = 0.0307 < 0.1, indicating that the risk weight assignment based on expert 1 data is valid.

Table 6: Risk evaluation index consistency judgment matrix

	I1	I2	I3	I4	I5	w
I1	1.000	0.333	0.250	0.200	3.000	0.084
I2	3.000	1.000	0.500	0.333	5.000	0.177
I3	4.000	2.000	1.000	0.500	6.000	0.273
I4	5.000	3.000	2.000	1.000	7.000	0.425
I5	0.333	0.200	0.167	0.143	1.000	0.042
λ max=5.14 CI=0.0344 CR=0.0307<0.1 (Passing consistency testing)						

In the same way, the weight values of other expert evaluation indexes are calculated. The consistency ratio has the condition that CR < 0.1, therefore all judgment matrices satisfy the consistency requirement. The result values of the weightings for the first-grade indices of the risk evaluation of the barracks facility renewal unit in the high-altitude cold area are displayed in Table 7.Since the assignment results of 10 experts' data are valid, the weight calculation of each criterion level indicator takes the arithmetic average of the assignment results of all experts, i.e., the weights of natural risk (I1), economic risk (I2), environmental risk (I3), management risk (I4), and security risk (I5) are 0.085, 0.165, 0.276, 0.429, and 0.045, respectively.

Table 7: Risk evaluation criteria layer index score results

	I1	I2	I3	I4	I5
Expert 1	0.084	0.177	0.273	0.425	0.042
Expert 2	0.072	0.166	0.291	0.423	0.048
Expert 3	0.077	0.156	0.282	0.453	0.032
Expert 4	0.095	0.184	0.267	0.423	0.031
Expert 5	0.088	0.155	0.274	0.422	0.061
Expert 6	0.092	0.136	0.276	0.431	0.065
Expert 7	0.081	0.179	0.275	0.437	0.028
Expert 8	0.077	0.186	0.265	0.418	0.054
Expert 9	0.083	0.147	0.282	0.425	0.063
Expert 10	0.105	0.163	0.274	0.431	0.027
Arithmetic mean	0.085	0.165	0.276	0.429	0.045

Secondly, the weight of each secondary indicator under the primary indicator is determined. According to the above calculation process, The computation of the weight for every secondary indicator can be conducted in a similar way. Table 8 gives the results that experts have given weights to every second-level indicator which is under natural risk (I1). Finally, the arithmetic average weights of natural disasters (I11) and severe climate (I22) are 0.505 and 0.495 respectively.

Table 8: The results of the I1 on the substandard layer

	I11	I12
Expert 1	0.250	0.750
Expert 2	0.500	0.500
Expert 3	0.750	0.250
Expert 4	0.800	0.200
Expert 5	0.500	0.50
Expert 6	0.250	0.750
Expert 7	0.500	0.500
Expert 8	0.750	0.250
Expert 9	0.250	0.750
Expert 10	0.500	0.50
Arithmetic mean	0.505	0.495

The results of the experts' weighting of the secondary indicators under economic risk (I2) are shown in Table 9. The average weighting values of the loan interest rate (I21), price increase (I22), and the terms of the claim not yet known or unclear (I23) are 0.235, 0.376, and 0.389, respectively.

Table 9: The results of the I2 on the substandard layer

	I21	I22	I23
Expert 1	0.210	0.386	0.404
Expert 2	0.153	0.416	0.431
Expert 3	0.264	0.361	0.375
Expert 4	0.264	0.333	0.403
Expert 5	0.320	0.445	0.235
Expert 6	0.161	0.428	0.411
Expert 7	0.333	0.344	0.323
Expert 8	0.176	0.328	0.496
Expert 9	0.280	0.396	0.324
Expert 10	0.190	0.322	0.488
Arithmetic mean	0.235	0.376	0.389

Table 10 shows the results that experts give weight values to the second-level indicators in the environmental risk kind (I3).The average weights of ecological damage (I31), imperfect laws and regulations (I32), and changes in construction approval procedures (I33) are 0.421, 0.192, and 0.387 in that order.

Table 10: The results of the I3 on the substandard layer

	I31	I32	I33
Expert 1	0.438	0.188	0.374
Expert 2	0.391	0.236	0.373
Expert 3	0.388	0.225	0.387
Expert 4	0.395	0.222	0.383
Expert 5	0.480	0.232	0.288
Expert 6	0.471	0.154	0.375
Expert 7	0.368	0.208	0.424
Expert 8	0.380	0.162	0.458
Expert 9	0.405	0.154	0.441
Expert 10	0.495	0.142	0.363
Arithmetic mean	0.421	0.192	0.387

The results of the experts' assignment of the secondary indicators under management risk (I4) are shown in Table 11. The average weights of moral risk (I41), information deficiency risk (I42), and management capability risk (I43) were obtained as 0.217, 0.408, and 0.375, respectively.

Table 11: The results of the I4 on the substandard layer

	I41	I42	I43
Expert 1	0.155	0.411	0.434
Expert 2	0.251	0.372	0.377
Expert 3	0.256	0.430	0.314
Expert 4	0.207	0.347	0.446
Expert 5	0.167	0.437	0.396
Expert 6	0.194	0.371	0.435
Expert 7	0.265	0.399	0.336
Expert 8	0.213	0.420	0.367
Expert 9	0.229	0.443	0.328
Expert 10	0.232	0.450	0.318
Arithmetic mean	0.217	0.408	0.375

Table 12 gives the results that experts gave weights to the second-level indicators inside the security risk kind (I5). The weights which are distributed to the personnel safety risk (I51) and the equipment safety risk (I52) both are 0.5.

Table 12: The results of the I5 on the substandard layer

	I51	I52
Expert 1	0.500	0.500
Expert 2	0.250	0.750
Expert 3	0.750	0.250
Expert 4	0.500	0.500
Expert 5	0.750	0.250
Expert 6	0.250	0.750
Expert 7	0.250	0.750
Expert 8	0.750	0.250
Expert 9	0.500	0.500
Expert 10	0.500	0.500
Arithmetic mean	0.500	0.500

In the end, the total weight of each risk factor grade is calculated, and the results of the total weight calculation for each index are obtained, which is shown in Table 13. It can be seen from the calculation results that a barracks facility project in the high alpine region of the Tibetan Plateau on behalf of the unit in ecological damage (I31), changes in the construction approval process (I33), lack of information (I42), and the management capacity (I43) accounted for a large proportion of risk, accounting for a proportion of 55.9% of the weight. Regarding the ABC categorization, these four dangers are the main risks that the unit has met.

Table 13: The composite weight calculation results of each index

	I1	I2	I3	I4	I5	Composite weight
	0.085	0.165	0.276	0.429	0.045	
I11	0.505					0.043
I12	0.495					0.042
I21		0.235				0.039
I22		0.376				0.062
I23		0.389				0.064
I31			0.421			0.116
I32			0.192			0.053
I33			0.387			0.107
I41				0.217		0.093
I42				0.408		0.175
I43				0.375		0.161
I51					0.500	0.023
I52					0.500	0.023
Total	1	1	1	1	1	1

4.2 Fuzzy evaluation of the risk of the agency for the barracks project

(1) Establishment of risk evaluation factor set

As can be seen from the risk evaluation model constructed above, through adopting level analysis, we can clearly discover that the weight values of the risk evaluation indexes for a barrack construction project in the high-altitude region of the Tibetan Plateau are accurately obtained. At the same time, the collection of risk evaluation elements for this barracks construction project in the high-altitude area of the Tibet Plateau is calculated. Table 14 shows the set of risk evaluation factors for a barracks facility project in the alpine region of the Tibetan Plateau.

Table 14: Project risk assessment factor

The first evaluation factors	Number	The second evaluation factor	Number
Natural risk	I1	Disaster risk (low temperature, permafrost, glacier, ultraviolet light, etc.)	I11
		Bad weather	I12
Economic risk	I2	Loan rate	I21
		Price rise	I22
		The claim clause is unclear or missing	I23
Environmental risk	I3	Ecological destruction	I31
		The laws and regulations are not perfect	I32
		Construction approval procedure changes	I33
Management risk	I4	Moral hazard	I41
		Information deletion risk	I42
		Managerial ability risk	I43
Safety risk	I5	Personnel safety risk	I51
		Equipment safety risk	I52

(2) Establishment of risk evaluation level

The risk assessment assembly which belongs to the replacement construction project is expressed as V, in which V = {V1, V2, V3, V4, V5}. The grades of risk evaluation are divided as big, relatively high, middle, small, and super small. The corresponding points that are given to these grades are 5, 4, 3, 2, and 1 one by one.

(3) Fuzzy overall evaluation of risks by using the AHP (Analytic Hierarchy Process) level analysis method

One all-sided risk assessment, which uses the AHP layer analysis method, has been conducted. One risk evaluation measurement form has been worked out for one barracks facility project that is situated in the alpine region of the Tibetan Plateau. This form was afterwards given out to ten experts and researchers that have taken part in the AHP part of this research. The task that they must complete is to assess the risk degree under the framework of the related risk groups and the combinations of the given risk assessment degrees.The data that we collected from 15 professional appraisal question sheets were entered into the program that was made for Analytic Hierarchy Process (AHP)-based fuzzy overall evaluation. This procedure was implemented to compute the risk grade of a contractor for a barracks building project in the high-altitude zones of the Tibet Plateau. We present the results in Table 15.

Table 15: The risk score of the construction unit

The first evaluation factors	Weighted score	The second evaluation factor	Weighted score
I1	3.59	I11	3.84
		I12	3.33
I2	2.81	I21	3.23
		I22	2.59
		I23	2.78
I3	2.21	I31	1.53
		I32	2.11
		I33	3.00
I4	2.06	I41	2.43
		I42	2.15
		I43	1.76
I5	3.25	I51	3.38
		I52	3.11
Integrated risk=3.59*0.085+2.81*0.165+2.21*0.276+2.06*0.429+3.25*0.045=2.41			

(4) Comprehensive Evaluation

The results show that natural disasters (I11), adverse weather (I22), loan interest rates (I21), changes in construction approval procedures (I33), personnel safety risks (I51), and equipment safety risks (I52) are in the category of larger risks, and within the general risks are price increases (I22), claim terms that are not yet clear or unclear (I23), and imperfect laws and regulations (I32), moral risk (I41) and lack of information risk (I42), and lower risks are ecological damage (I31) and management ability risk (I43). Through calculation, many risk factors which are related to a barracks construction project which lies in the high-altitude region of the Tibetan Plateau have values that lie between 2 and 3, 3 and 4, which are categorized as general risk and greater risk, and the agency's comprehensive risk score is 2.41, which is a lower risk and needs to focus on taking countermeasures.

5 Conclusion

This research thesis establishes an index system which may be utilized for the risk assessment of a barracks engineering construction unit in the high cold region of the plateau. Through the making of a related questionnaire and the utilization of the AHP level analysis method, on the foundation of evaluation data of risk indices given by specialists, it carries out the identification and examination of weights of risk assessment indices for the construction main body.At the same time, a risk assessment aggregate and risk categorization have been worked out by the researchers. One fuzzy comprehensive risk assessment which uses the AHP hierarchical analysis method is then carried out for one replacement construction unit of barracks facilities in the high-altitude cold regions of the Qinghai-Tibetan Plateau.The risk evaluating system of the already built substitute unit contains five first - grade standards, including natural dangers, and 13 second - grade standards, just like natural disasters.In this case study, the Analytic Hierarchy Process (AHP), which is a method of hierarchical analysis, have drawn the conclusion that the arithmetic mean weights of first-tier indicators are in the range from 0.045 to 0.429. In addition, it has been discovered that the composite weights of the second-tier indicators lie in the interval between 0.023 and 0.175.Furthermore, the overall risk degree of the construction main body in the case analysis is situated in a low-risk situation. This circumstance includes six comparatively important danger elements, five common danger elements, and two not so obvious danger elements.The Analytic Hierarchy Process, which is one hierarchical analysis method, provides one usable frame structure for confirming the weight values of risk assessment indexes for the construction main body of barracks installations in high altitude and extreme cold regions.

About the Author

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