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Research Article

Research on Intelligent Evaluation Model of Railway Internationalized Earthquake Emergency Rescue Talents Based on Analytic Hierarchy Process and Fuzzy Theory

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Earthquakes occur frequently in the 21st century and cause a large number of casualties; induced secondary geological disasters will cause more serious casualties. How to reasonably deal with the earthquake disaster to carry out emergency rescue work is becoming increasingly urgent; the ability level of earthquake disaster emergency rescue personnel is directly related to the follow-up relief effect. Based on this, aiming at the emergency rescue ability of nationalized railway management talents in high-intensity earthquake areas around the world, this paper will use the methods of analytic hierarchy process and fuzzy theory to construct an intelligent evaluation model of railway international earthquake emergency rescue personnel ability. In addition, this paper carries out a questionnaire survey of experts in related fields and model empirical research and puts forward optimization measures and suggestions for the personnel training of railway international earthquake emergency rescue in high-intensity seismic areas based on the results of model evaluation.

1. Introduction

The "National Medium and Long-term Education Reform and Development Plan Outline (2010–2020)" pointed out that international talents refer to talents who have an international vision, are familiar with international rules, and can participate in international affairs and international competition. Earthquakes occur frequently in the 21st century and will directly cause railway deformation (see Figures 1(a) and 1(b)), causing a lot of economic losses and casualties; induced secondary geological disasters will cause more serious casualties. How to reasonably deal with the earthquake disaster to carry out emergency rescue work is becoming increasingly urgent; the ability level of earthquake disaster emergency rescue personnel is directly related to the follow-up relief effect [1–5]. With the deepening of overseas railway projects, there are a large number of lines located in high-intensity earthquake areas, such as Indonesia Yawan high-speed railway (see Figures 2 & 3), earthquakes occur frequently and do great harm (see Figures 4–7) [6–10], and the talent team cannot meet the needs of rapid growth in terms of scale or quality. This paper constructs a model for evaluating the ability of railway international earthquake emergency rescue talents based on fuzzy theory, analytic hierarchy process, expert investigation, and other methods. Based on the model analysis, the key ability elements and training optimization measures for railway international emergency rescue personnel in high-intensity earthquake areas are put forward.

1.1. Overview of Research on Emergency Rescue Capability. "Competency" is usually called "emergency rescue capability" in high-speed railway response to earthquake disasters, which reflects the expression of the comprehensive ability of emergency rescue personnel to deal with earthquake disasters, which will be studied systematically in this paper. The concept of "competency" originated in the field of American psychology. It is one of the methods to replace traditional intelligence tests to measure personal work ability and performance. It is widely used in education, business, and other fields. In 1953, David McClelland, a professor of

(a) (b)

Figure 1: The earthquake paralyzed the railway system.

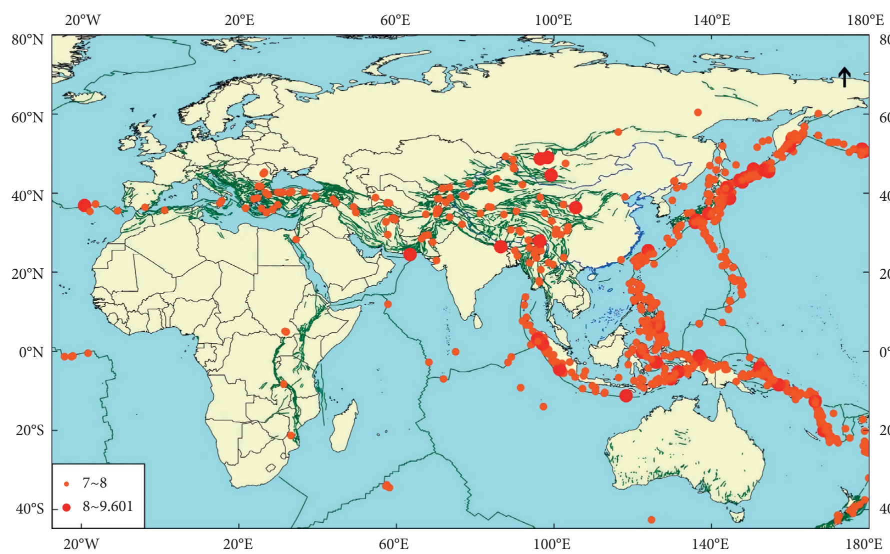

Figure 2: Distribution diagram of historical earthquakes with magnitude 7 and above in the world.

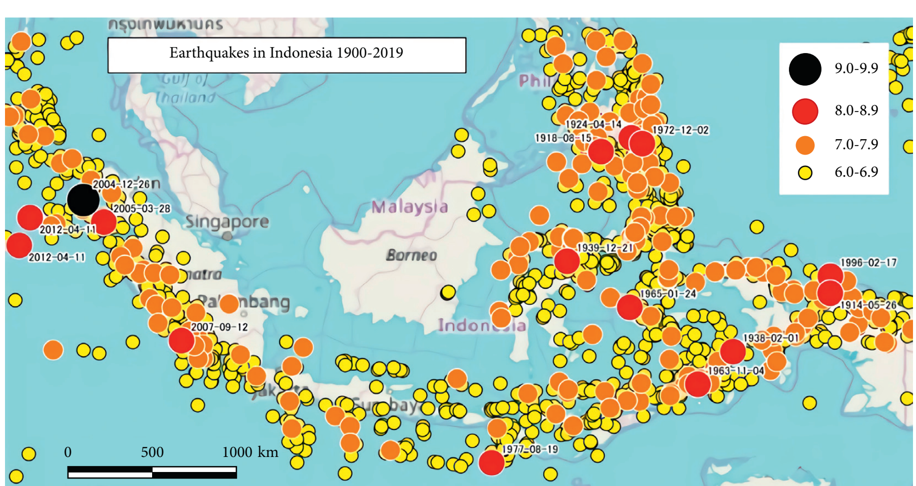

Figure 3: Seismic intensity distribution along the Yawan high-speed railway in Indonesia.

Figure 4: The armed police are carrying out emergency rescue during the May 12, 2008, Wenchuan earthquake.

Figure 5: Rescue workers in a collapsed building after the earthquake in Christchurch, New Zealand, February 23, 2011.

Figure 6: Dam damage caused by earthquake.

Figure 7: Landslide caused by earthquake to form dammed lake.

psychology at Harvard University, proposed in the paper "testing for competence rather than for intelligence"[11] that academic talent and knowledge structure in the traditional sense are important factors to measure academic ability, but it is difficult to evaluate work ability or performance. He believes that the measurement of work ability is an implicit and lasting personal trait, which is called "competency." In 1982, Richard Boyatzis applied the competency probability to the business field. In his book "Competent Managers"[12], he defined competence as a potential personal trait of high efficiency and outstanding performance at work, including motivation, characteristics, skills, personal image, social role, and knowledge system. Hornby and Thomas [13] and Jacobs [14] apply competence to the field of human resource management, believing that competence is the embodiment of effective management ability in the work environment and believes that this ability is observable. Spencer and Spencer [15] pointed out that competence is a potential characteristic possessed by excellent employees, including motivation, personal traits, self-awareness, knowledge, and skills. Brown [16] further elaborated that competency is the ability required to meet the goals of a certain position in the workplace environment. It can be standardized and evaluated as the entry screening condition, which is also the basis of training and professional certification.

2. Construction of an Index System for the Ability of Earthquake Emergency Rescue Personnel

2.1. Identification of Emergency Rescue Capability Elements. Taking railway internationalized operation and management talents as the object, through literature research, recruitment case analysis, and expert interviews, the competency indicators are screened and classified to form the key elements of the competence for international talents.

Based on the literature research method, it sorts out more than 30 international talents' competency research literature on HowNet, extracts and conceptualizes competency features, and counts the frequency of competency features.

Similarly, based on the case analysis method, through sorting out Worry-Free Recruitment, Zhilian Recruitment, and other websites, recruitment requirement of 41 international project managers from many railway construction and emergency equipment manufacturing companies such as Siemens, Alstom, China Railway, China Railway Engineering, CRRC, China Communications, and China Hydropower is collected. For management positions, competency characteristics are extracted and the frequency of occurrence is counted, as shown in Table 1:

2.2. The Ability Index System of Emergency Rescue Talents. On the basis of identifying the ability characteristics of international emergency rescue talents based on literature research and recruitment case analysis and through investigating more than 30 middle and senior managers participating in railway overseas projects, the

Table 1: Statistical frequency of emergency rescue capability characteristics.

Competency index	Frequency of literature statistics	Recruitment statistics index frequency	Subtotal
Professional knowledge	10	38	48
International perspective	9	34	43
Communication skills	15	27	42
Management ability of emergency rescue project	10	28	38
Sense of responsibility	12	19	31
Integrity and confidence	9	19	28
Compressive ability	12	15	27
Teamwork	6	14	20
Political literacy	5	15	20
International business knowledge of emergency rescue	4	14	18
Emergency rescue capability	6	8	14
Information acquisition and processing capabilities	8	5	13
Ability to learn quickly in local customs	4	5	9

competence characteristics of the indicator system for international talents are listed and optimized, the indicator definitions are clarified, and the categories are sorted and integrated, as shown in Figure 8, categorizing to form three first-level indicators of knowledge, skills, and professionalism and 15 second-level indicator systems details as follows:

(1) Knowledge: the professional knowledge of emergency rescue that employees must possess for a specific job

(2) Skills: the ability to master and apply certain professional knowledge of emergency rescue to complete specific tasks

(3) Professionalism: the ideology, ethics, awareness, and behavior habits that employees should possess when engaging in a specific position of emergency rescue

Definition and description of competency index:

(i) Railway engineering knowledge: master and understand all links and procedures in railway engineering construction, be familiar with construction process, engineering materials, and construction technology, and know technical specifications and quality inspection and control procedures.

(ii) Knowledge of earthquake risk prevention and control: understand the laws and regulations on target market access, foreign investment approval, foreign exchange supervision, national security review, and employment.

(iii) Knowledge of emergency rescue fund management: master international financial management, foreign exchange management, corporate finance, international investment management, international taxation, etc.

(iv) International perspective: familiar with international practices, with the international frontier knowledge of emergency rescue of this major, with the ability to operate internationally, and with experience in overseas engineering project development of emergency rescue.

(v) International emergency rescue legal knowledge: including international trade, foreign investment, international finance, international business negotiation, international etiquette, and other knowledge systems, familiar with the work process of overseas project bidding, business negotiation, contract writing, etc.

(vi) Communication skills: individuals can correctly listen to the voices of the rescued and emergency rescue teams, feel their feelings, needs, and opinions, and have the ability to respond appropriately, to listen, speak, read, and write in at least one international common language, and to communicate across cultures.

(vii) Information acquisition and processing capabilities: obtain the new technical information of emergency rescue through the Internet and interpersonal network, fully understand the new technical information, and use the information to speed up the development of emergency rescue work.

(viii) Emergency rescue ability: employees can quickly understand the intentions of their superiors at work and then form goals and formulate concrete and feasible action plans, rationally use relevant resources, implement the plan, and achieve the work goals.

(ix) Emergency rescue project management ability: employees plan the project schedule, organize, and implement project management according to the project schedule plan and do a good job in project quality, safety, risk, contract, cost, and other management tasks.

(x) Ability to learn rapidly in local customs: master the customs of the place where the disaster occurred and be able to quickly adjust and adapt according to their own characteristics.

(xi) Sense of responsibility: employees are responsible for what they do, take responsibility for others, and consciously perform their obligations to the organization.

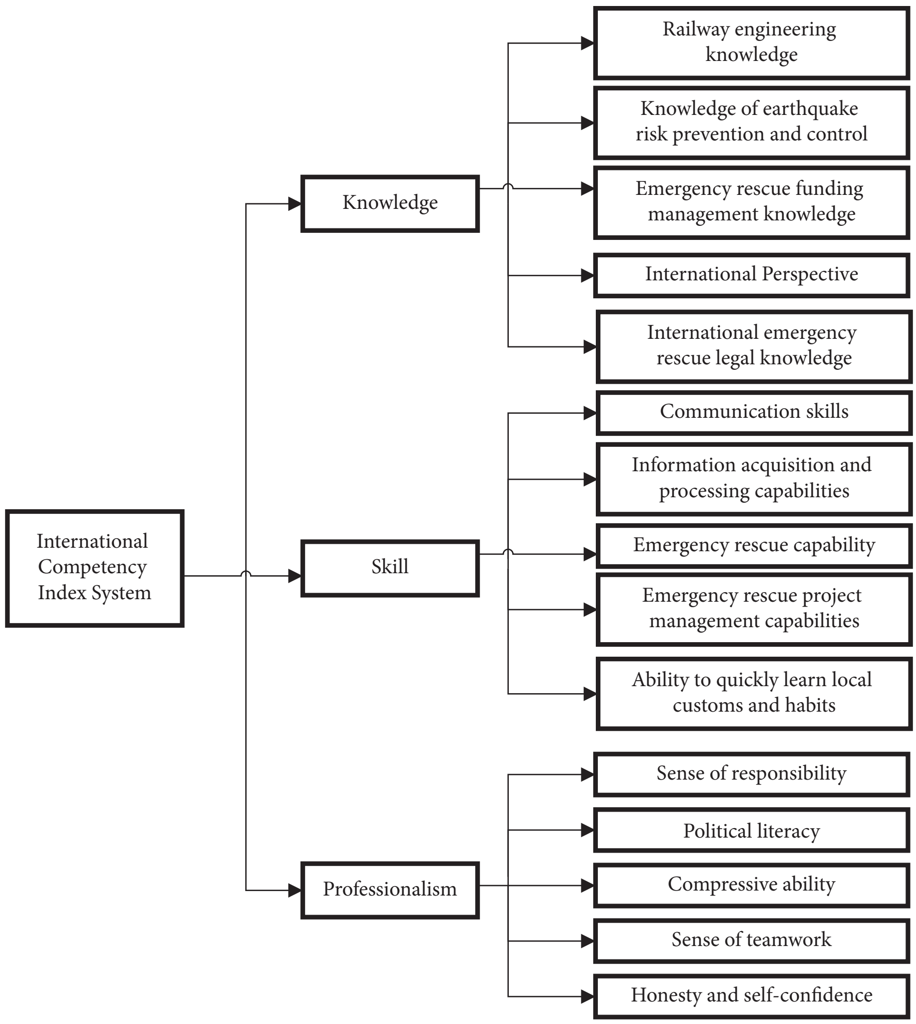

Figure 8: Ability index system of railway international emergency rescue personnel in high-intensity earthquake area.

(xii) Political literacy: employees are loyal to the country, trust in their work, team, and organization, and are aware of the importance of the country and collective interests in key events

(xiii) Compressive ability: the strength of adaptability, tolerance, endurance, and ability to overcome adversity overseas earthquake disasters.

(xiv) Teamwork literacy: have a holistic view, be able to obey commands, cooperate with others according to the needs of work goals, coordinate various relationships, mobilize the enthusiasm of all parties, and be able to deal with and solve various problems in the work in a timely manner.

(xv) Integrity and confidence: good conduct, honesty, and decent, self-belief in one's own views, decisions, and tasks, and the ability to solve problems effectively. The first priority is to save the safety of life and property in the process of earthquake.

3. Construction of Competency Model Based on Fuzzy Analytic Hierarchy Process

The analytic hierarchy process is a system qualitative and quantitative analysis method. The basic principle is to decompose the research object into a hierarchical structure according to the system composition, establish a hierarchical multilevel structure model, and systematically clarify the relationship between various factors that affect the evaluation. Then, adopting the Delphi method, relative importance of each factor at the same level is compared and justified according to the corresponding scoring rules, and finally, the relevant index weight is obtained.

However, in the traditional analytic hierarchy process, when constructing the judgment matrix based on the expert score, the only specific value is obtained, and the constructed matrix is an ideal situation that does not allow deviation. In the actual index comparison process, people often have fuzzy feelings in their judgments, and the true value is often within an interval range. In order to reflect the cognitive information of experts more comprehensively and obtain a more scientific evaluation result, the triangular fuzzy function theory is incorporated in the construction of the judgment matrix, and the traditional single importance value is converted into fuzzy numerical intervals with upper and lower bounds which is helpful to scientifically and quantitatively deal with information problems in fuzzy environments [17].

3.1. Triangular Fuzzy Number. Define if the membership function of fuzzy number A is

$$\mu_A x = \begin{cases} \dfrac{x}{m-l} - \dfrac{l}{m-l}, & x \in [l,m], \\ \dfrac{x}{m-u} - \dfrac{u}{m-u}, & x \in [m,u], \\ 0, & x \notin [l,u], \end{cases} \tag{1}$$

where x: $[l,m]$ is continuous and strictly increasing and x: $[m,u]$ is continuous and strictly decreasing and satisfies $l < m < u$ and $l, m, u \in R$. Then, the fuzzy number A is a triangular fuzzy number, denoted as $A = l, m, u$. Among them, l is the lower limit, u is the upper limit, and m is the possible value [18].

3.2. Construct a Triangular Fuzzy Judgment Matrix [19]. With n evaluation indicators, the constructed judgment matrix is $B = (b_{\text{ij}})_{n\times n}$, where $b_{ij} = [l_{ij}, m_{ij}, u_{ij}]$ is a closed interval with m_{ij} as the median and $b_{ji} = b_{ij}^{-1} = [u_{ij}^{-1}, m_{ij}^{-1}, l_{ij}^{-1}]$.

If there are a number of K experts jointly participating in the judgment, at this time, b_{ij} is a comprehensive triangular fuzzy number, and its value is obtained by the following formula:

$$b_{ij} = \frac{1}{K} \otimes \left(b_{ij}^1 + b_{ij}^2 + \cdots + b_{ij}^k\right) (k = 1, 2, \ldots, K). \tag{2}$$

After more than 30 experts in railway engineering, railway economics, railway logistics, commerce and trade, transportation planning and management, human resources, and other related fields scored, the four triangular fuzzy judgment matrices B_i $(i = 1, 2,3,4)$ are as follows:

$$B1 = \begin{bmatrix} (1,1,1) & (4,5,6) & (6,7,8) \\ \left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right) & (1,1,1) & (4,5,6) \\ \left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right) & \left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right) & (1,1,1) \end{bmatrix},$$

$$B2 = \begin{bmatrix} (1,1,1) & (4,5,6) & (6,7,8) & (5,6,7) & (5,6,7) \\ \left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right) & (1,1,1) & (5,6,7) & (6,7,8) & (1,2,3) \\ \left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right) & \left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right) & (1,1,1) & \left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right) & \left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right) \\ \left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right) & \left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right) & (3,4,5) & (1,1,1) & (1,2,3) \\ \left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right) & \left(\frac{1}{3},\frac{1}{2},1\right) & (4,5,6) & \left(\frac{1}{3},\frac{1}{2},1\right) & (1,1,1) \end{bmatrix},$$

$$B3 = \begin{bmatrix} (1,1,1) & (5,6,7) & (1,2,3) & (6,7,8) & (3,4,5) \\ \left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right) & (1,1,1) & \left(\frac{1}{6},\frac{1}{5},\frac{1}{4}\right) & \left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right) & \left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right) \\ \left(\frac{1}{3},\frac{1}{2},1\right) & (4,5,6) & (1,1,1) & (3,4,5) & (3,4,5) \\ \left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right) & (2,3,4) & \left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right) & (1,1,1) & (1,2,3) \\ \left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right) & (2,3,4) & \left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right) & \left(\frac{1}{3},\frac{1}{2},1\right) & (1,1,1) \end{bmatrix},$$

$$B4 = \begin{bmatrix} (1,1,1) & (1,2,3) & (5,6,7) & (7,8,9) & (7,8,9) \\ \left(\frac{1}{3},\frac{1}{2},1\right) & (1,1,1) & (5,6,7) & (5,6,7) & (7,8,9) \\ \left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right) & \left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right) & (1,1,1) & (3,4,5) & (6,7,8) \\ \left(\frac{1}{9},\frac{1}{8},\frac{1}{7}\right) & \left(\frac{1}{7},\frac{1}{6},\frac{1}{5}\right) & \left(\frac{1}{5},\frac{1}{4},\frac{1}{3}\right) & (1,1,1) & (2,3,4) \\ \left(\frac{1}{9},\frac{1}{8},\frac{1}{7}\right) & \left(\frac{1}{9},\frac{1}{8},\frac{1}{7}\right) & \left(\frac{1}{8},\frac{1}{7},\frac{1}{6}\right) & \left(\frac{1}{4},\frac{1}{3},\frac{1}{2}\right) & (1,1,1) \end{bmatrix}. \tag{3}$$

According to the above fuzzy judgment matrix, the fuzzy evaluation factor matrix R is constructed, and the calculation formula is as follows:

$$R = \left(r_{ij}\right) n \times n = \begin{bmatrix} 1 & 1 - \dfrac{u_{12} - l_{12}}{2m_{12}} & \cdots & 1 - \dfrac{u_{1n} - l_{1n}}{2m_{1n}} \\ 1 - \dfrac{u_{21} - l_{21}}{2m_{21}} & 1 & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ 1 - \dfrac{u_{n1} - l_{n1}}{2m_{n1}} & \cdots & \cdots & 1 \end{bmatrix}. \quad (4)$$

Calculate and adjust the judgment matrix Q:

$$Q = M \times R = \begin{bmatrix} 1 & m_{12} & \cdots & m_{1n} \\ m_{21} & 1 & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ m_{n1} & \cdots & \cdots & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 1 - \dfrac{u_{12} - l_{12}}{2m_{12}} & \cdots & 1 - \dfrac{u_{1n} - l_{1n}}{2m_{1n}} \\ 1 - \dfrac{u_{21} - l_{21}}{2m_{21}} & 1 & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ 1 - \dfrac{u_{n1} - l_{n1}}{2m_{n1}} & \cdots & \cdots & 1 \end{bmatrix}. \quad (5)$$

In the formula, matrix M is a matrix composed of the median values of all triangular fuzzy numbers in the judgment matrix.

Convert the adjusted judgment matrix Q into a judgment matrix with a diagonal of l in columns, and record it as the final judgment matrix P; then, $P = (p_{ij}) n \times n$ and $P_{ij} = 1/p_{ji}$.

3.3. Determine the Weight. Using the tomographic analysis method and combining the triangular fuzzy judgment matrix, the weight is determined and the consistency check is performed [19], the above calculation process is realized through the python language, and the results are as follows:

Hierarchical single sort CR	CR1=0.014187<0.1
	CR2=0.000201<0.1
	CR3=0.015965<0.1
	CR4=0.015583<0.1
Total rank order CR	CR1=0.014187<0.1
	CR2=0.014388<0.1
	CR3=0.030152<0.1
	CR4=0.029770<0.1

The consistency index CR of single-level ranking and total-level ranking are both less than 0.1, indicating that the above judgment matrix has good consistency. According to the model calculation, the weight of each indicator is as follows:

Secondary indicators and weights	Three-level indicator layer	Hierarchical single sort weight	Total ranking weight
Knowledge(Z) W(Z)=0.63	Railway engineering knowledge (Z1)	W(Z1)=0.430	W(Z1)=0.271
	□ Knowledge of earthquake risk prevention and control (Z2)	W(Z2)=0.284	W(Z2)=0.180
	Emergency Rescue funds Management knowledge (Z3)	W(Z3)=0.032	W(Z3)=0.020
	□ International Perspective (Z4)	W(Z4)=0.126	W(Z4)=0.080
	International Emergency Rescue legal knowledge (Z5)	W(Z5)=0.128	W(Z5)=0.081
Skills(J) W(J)=0.30	Communication skills (J1)	W(J1)=0.418	W(J1)=0.126
	Information acquisition and processing capabilities (J2)	W(J2)=0.043	W(J2)=0.013
	Emergency rescue capability (J3)	W(J3)=0.301	W(J3)=0.091
	Emergency Rescue Project Management ability (J4)	W(J4)=0.133	W(J4)=0.040
	Ability to learn rapidly in local customs (J5)	W(J5)=0.105	W(J5)=0.032
Professionalism(Y) W(Y)=0.07	Sense of responsibility (Y1)	W(Y1)=0.383	W(Y1)=0.025
	Political literacy (Y2)	W(Y2)=0.331	W(Y2)=0.022
	Compressive ability (Y3)	W(Y3)=0.190	W(Y3)=0.012
	Teamwork literacy (Y4)	W(Y4)=0.070	W(Y4)=0.005
	Integrity and confidence (Y5)	W(Y5)=0.026	W(Y5)=0.002

According to the expert evaluation results, the second-level index weights are ranked as follows: knowledge (0.63), skills (0.30), and professionalism (0.07). The order of three-level indicator weight is railway engineering knowledge (0.271), knowledge of earthquake risk prevention and control (0.180), emergency rescue funds management knowledge (0.020), international perspective (0.080), international emergency rescue legal knowledge (0.081), communication ability (0.126), information acquisition and processing ability (0.013), emergency rescue capability (0.091), emergency rescue project management ability (0.040), ability to learn rapidly in local customs (0.032), sense of responsibility (0.025), political literacy (0.022), compressive ability (0.012), sense of teamwork (0.005), and integrity and self-confidence (0.002). From the analysis of indicator weights, it can be seen that the weight ratio of knowledge is the highest, skills are second, and professionalism is the lowest. According to the index weight analysis, the weight proportion of knowledge is the highest, the skill is the second, and the professional accomplishment is the lowest. Among them, railway engineering knowledge, knowledge of earthquake risk prevention and control, communication ability, information acquisition and processing ability in skill module, sense of responsibility, and political literacy in professional accomplishment module are prominent in the knowledge module. They need to be targeted for personal literacy and existing knowledge base and training.

4. Conclusion

Through the above research, the following conclusions are drawn:

(1) In this study, the evaluation model of emergency rescue ability of international talents of railway management in high-intensity earthquake area is established, which can cover three types of knowledge, skills, professional accomplishment, and 15 secondary indicators and quantitatively determine the influence weight of different impact indicators. It will point out the direction for the follow-up international earthquake disaster emergency rescue personnel training.

(2) The construction of the evaluation system of emergency rescue ability is helpful to build a unified talent standard, identify the gap between employee current competency level and job demand, customize the training plan of personnel, enhance the pertinence of training, improve the effectiveness of training, help employees to improve their performance, and realize modular design for the training of earthquake emergency rescue personnel of high-speed railway in high-intensity areas. Then, comprehensively improve the comprehensive quality and level of earthquake emergency rescue personnel.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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