Exploration of Safety Culture Construction and Management in Rail Transit Enterprises

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Abstract. In order to enhance the level of safety culture construction and management capabilities of rail transit enterprises, this article analyzes the safety culture of enterprises, determines four main primary indicators and sixteen secondary indicators for evaluating enterprise safety culture, and uses the Analytic Hierarchy Process to establish an evaluation model to calculate the weights of each factor. Research shows that safety behavior culture has the greatest impact on the development of safety culture in rail transit enterprises (weight 0.4309), while safety concept culture has the smallest impact (weight 0.0963); In the secondary indicators, the impact of all staff safety incentives (weight 0.4661), safety technology standardization (weight 0.4173), and safety management behavior standardization (weight 0.2576) is the most significant, while the impact of enterprise platform safety publicity is the smallest (weight 0.0909). Therefore, in the process of building a corporate safety culture, it is necessary to attach importance to motivating and managing employees' safety behaviors, as well as strengthening the standardization of safety technology. In addition, in order to further quantify the evaluation of the enterprise safety culture system, the K-medoids algorithm was used to avoid noisy data, combined with the Analytic Hierarchy Process and Fuzzy Evaluation, to evaluate the safety culture construction level of Beijing Rail Transit Construction Co., Ltd. The evaluation results were basically consistent with the actual situation, verifying the effectiveness of the model and providing reference for the safety culture construction of other enterprises in the same industry.

Keywords: Rail Transit; Safety culture; business management.

1 Introduction

Safety culture can be understood as a collection of shared values, beliefs, attitudes, and behavioral patterns of employees within an organization with respect to safety [1]. As

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an important part of modern enterprise management, safety culture construction plays a key role in various industries. It not only concerns the health and life safety of employees, but also is the cornerstone of long-term development and sustainable operation of enterprises.

In manufacturing fields such as automobile manufacturing and electronics manufacturing, the building of a safety culture has a direct impact on the safety of production lines and the health of workers. Highly mechanized and automated production environments expose employees to a variety of potential hazards, such as mechanical injuries and chemical exposures [2], and by establishing a positive safety culture, companies can reduce accident rates, increase productivity, and enhance employee safety awareness. In the construction industry, where the work environment is complex and varied, involving high-risk work such as working at height and operating heavy machinery [3], the building of a safety culture requires not only the management to strengthen safety policies and procedures, but also the employees to fully understand and comply with the safety regulations in the actual operation to ensure that every aspect of the work process meets the safety standards, and effective safety cultures can significantly reduce the number of workplace accidents and workforce turnover, and improve project success and reputation [4-5]; in the healthcare field, safety culture is directly related to the life safety of patients and healthcare workers [6], and a good safety culture not only improves the efficiency and quality of healthcare services, but also enhances the professionalism and sense of responsibility of healthcare workers [7-8]; in the aerospace industry, the importance of safety culture here is reflected in the prevention of flight accidents, ground service operations, and pilot operational safety, among many others. Airlines and manufacturers need to ensure the safe completion of every flight mission through training, technological updating, and safety culture building to safeguard passengers and aircraft [9-11]; in the energy industry, the development of a safety culture is key to preventing major accidents and protecting the environment and the health of personnel. Organizations need to comply with strict safety standards and operating procedures, and improve the safety awareness and operating skills of their employees through continuous training and supervision to cope with complex and high-risk work environments [12-13].

While the importance of establishing a safety culture in all industries is widely recognized, its implementation still faces many challenges. There are differences in the safety risks and cultural backgrounds of different industries, requiring targeted strategies and measures. Due to the characteristics of urban rail transit, such as dense pedestrian flow, restricted space, and difficulty in rescuing people after accidents, its safety management has always been a key issue in urban safety. Therefore, this paper takes a rail transit construction and management company as an example, in order to improve the company's safety management ability and enhance the company's safety culture construction level, this paper focuses on analyzing the company's shortcomings and deficiencies in the construction of safety culture, corresponding to the actual situation of the various indicators, analyzing the reasons for the shortcomings and deficiencies, and proposing solutions.

2 Evaluation Method

2.1 Evaluation Index System for Safety Culture

Determine Evaluation Factors. The establishment of enterprise safety culture system is aimed at realizing the comprehensive safety of people, things and management, and prompting the staff to enter the state of independent management, so the safety culture system not only contains the four levels of safety culture construction: safety behavior culture, safety environment culture, safety concept culture, safety system culture, but also integrates the idea of enterprise safety, such as safety propaganda on the enterprise platform, the dynamic management of the work of safety, the standardization of safety management behavior, and the standardization of safety technology will be the embodiment of the enterprise safety culture. behavior standardization, safety technology standardization will be the embodiment of enterprise safety culture. At present, a set of specific evaluation index system of enterprise safety culture has not yet been formed. Combined with the development requirements and practical application of safety culture, this paper proposes a set of safety culture evaluation index system including 4 first-level indexes and 16 second-level indexes in accordance with the principle of establishing the index system, which is shown in Figure 1.

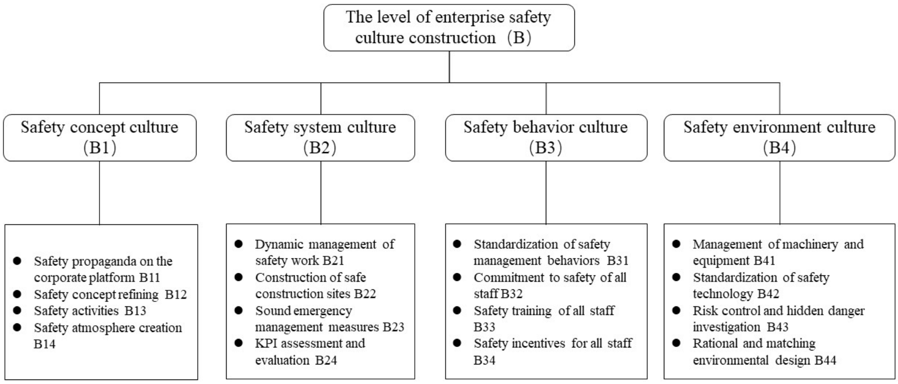

Fig. 1. Evaluation index system for enterprise safety culture

Determine the Weight of Evaluation Factors. The judgment matrix B of the criterion layer is as follows:

$$B = \begin{bmatrix} 1 & 1/2 & 1/3 & 1/4 \\ 2 & 1 & 1/2 & 1/3 \\ 3 & 2 & 1 & 3 \\ 4 & 3 & 1/3 & 1 \end{bmatrix}$$

Calculate the set of first level indicator weights B=[0.0963,0.1643,0.4309,0.3084]; λ=4.225827; $CI = \frac{\lambda - n}{n-1}$:0.075276; RI=0.89; CR=CI/RI=0.084579<0.1, So the judgment matrix satisfies the one-time verification of the Analytic Hierarchy Process, and the calculated weights are valid.

Similarly, the proportion and total ranking of all first-level and second-level indicators in the evaluation system of enterprise safety culture indicators are shown in Table 1.

Table 1. Weight distribution of each indicator in the enterprise safety culture assessment system

B	Weight	Secondary indicators	Weight	Total weight	Total sorting
B1	0.0963	B11	0.0909	0.0088	16
		B12	0.1667	0.0161	14
		B13	0.4244	0.0409	9
		B14	0.3141	0.0302	12
B2	0.1643	B21	0.4598	0.0755	6
		B22	0.0856	0.0141	15
		B23	0.2009	0.0330	11
		B24	0.2537	0.0417	8
B3	0.4309	B31	0.2576	0.1110	3
		B32	0.0950	0.0409	9
		B33	0.1813	0.0781	5
		B34	0.4661	0.2008	1
B4	0.3084	B41	0.1859	0.0573	7
		B42	0.4173	0.1287	2
		B43	0.3103	0.0957	4
		B44	0.0864	0.0266	13

2.2 Fuzzy Comprehensive Evaluation of Safety Culture

Evaluation Process. From the above process of fuzzy evaluation, it can be seen that after completing the determination of the factor set, it is necessary to further determine the rubric set and the degree of affiliation of each indicator. According to the knowledge theory of safety culture construction in this enterprise, the level of safety culture is finally divided into four levels, such as natural instinct, strict management, autonomous management, and mutual aid team, in which the corresponding level of mutual aid team is the highest level of the first level, and the others are decreasing one at a time. The classification of corporate safety culture evaluation levels is shown in Table 2.

Table 2. Classification of Enterprise Safety Culture Evaluation Levels

Evaluation value	Safety culture level	Current stage	measures recommended
[85,100)	Level I	Mutual aid team	Maintaining
[75,85)	Level II	Independent management	continual improvement
[60,75)	Level III	rigorous management	Development improvements
[0,60)	Level IV	natural instinct	build vigorously

According to the safety culture evaluation index system to establish the corresponding scoring table, the use of K-medoids algorithm, to avoid the noise data, so that the calculation results are more accurate. K-medoids is a data point-based cluster analysis method, different from the traditional K-means clustering method, its main feature is to use the center of the medoid (medoid) to represent the clusters, rather than simply use the mean value, so that the clustering results are more accurate and representative. using the mean, thus making the clustering results more accurate and representative.

In the K-medoids algorithm, the distance calculation is a key step that determines the similarity between each data point and the medoid, determines the cluster to which the data point should belong, and selects the new medoid in the update phase. The centroid can be defined as a point in the cluster that minimizes the difference with all other points in the cluster. The dissimilarity between the center point (Ci) and the object (Pi) is determined by using E = |Pi - Ci|.

The cost in K-Medoids algorithm is given as:

$$c = \sum_{Ci} \sum_{Pi \in Ci} |Pi - Ci| \tag{1}$$

In practical applications, it is crucial to choose the appropriate distance metric based on the characteristics of the data and the needs of the problem, and its Euclidean distance as well as Manhattan distance are common distance metrics and their calculation methods. Manhattan distance calculates the axis-aligned distance between points, which is more suitable for sparse data or datasets with non-uniform characteristics.

In d-dimensional space, the Manhattan distance is given by:

$$d(x_i, x_j) = \sum_{k=1}^{d} \left| x_{ik} - x_{jk} \right| \tag{2}$$

Using the 16,000 (16×1000) sets of evaluation data obtained from the firm, the data of instance B11 is shown in Figure 2. k points were randomly selected from the dataset as the initial medoids, followed by using the K-medoids algorithm, which assigns each sample point to the set of centroids closest to it based on the distance matrix by calculating the Euclidean distances between the points and re-computing the centroids to once again assign the points to the centroids , and the loop iterates until the medoids no longer change or some convergence criterion is reached. The calculation determines a K value of 3, as shown in Figure 3.

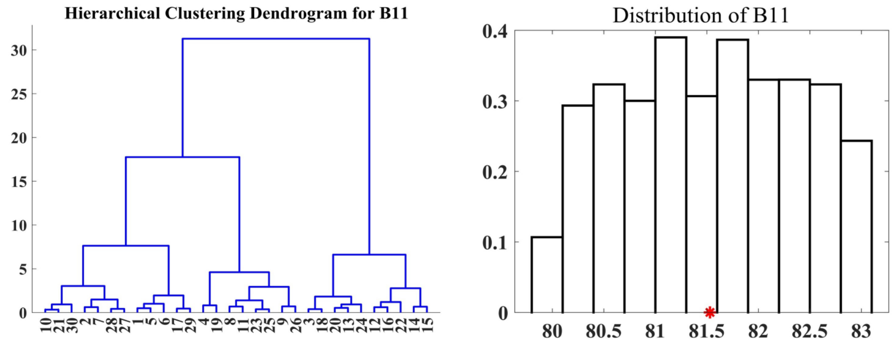

Fig. 2. Hierarchical Clustering Dendrogram for B11

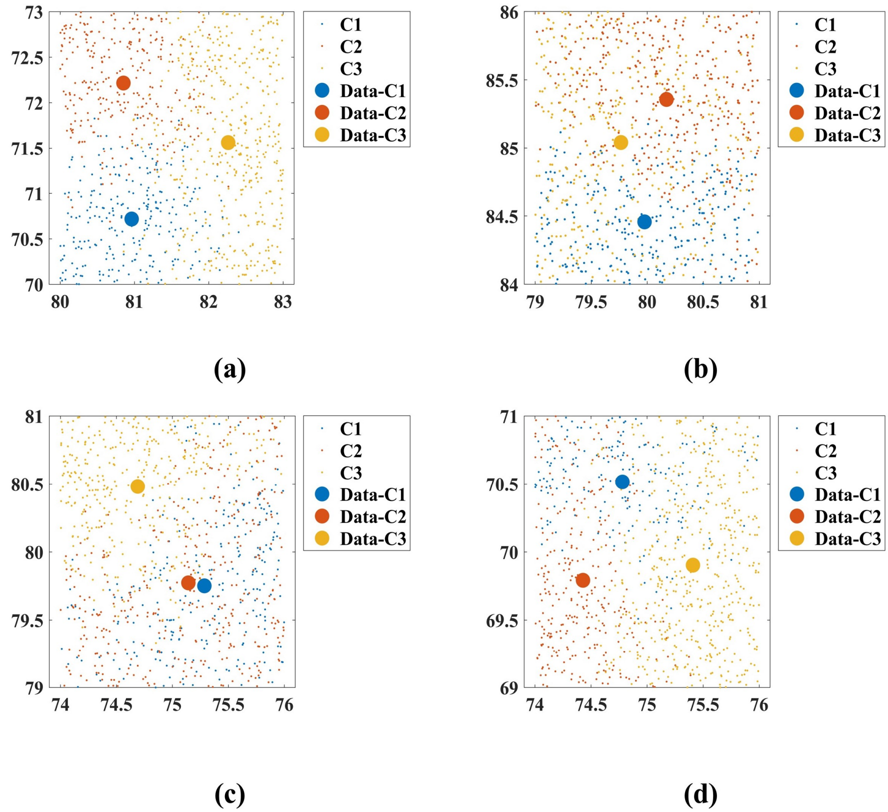

Fig. 3. (a)Safety concept culture B1 clustering results;(b)Safety system culture B2 clustering results;(c)Safety Behavior Culture B3 Clustering Results;(d)Safety Environment Culture B4 Clustering Results

The scores of each secondary indicator can be used to determine the evaluation level of the indicator. Statistics on the levels of each level of each secondary indicator were compiled to determine the percentage of each level, thus determining the single-factor affiliation of each secondary indicator, as shown in Table 3.

Table 3. Single-factor affiliation statistics

Primary indicators	secondary indicators	Level I	Level II	Level III	Level IV
B1	B11	0.2	0.7	0.1	0
	B12	0.2	0.5	0.2	0.1
	B13	0.3	0.4	0.3	0
	B14	0.1	0.7	0.1	0.1
B2	B21	0.1	0.6	0.3	0
	B22	0.3	0.5	0.2	0
	B23	0.1	0.7	0.1	0.1
	B24	0.2	0.6	0.2	0
B3	B31	0.2	0.5	0.3	0
	B32	0.1	0.6	0.3	0
	B33	0.2	0.5	0.2	0.1
	B34	0.2	0.6	0.2	0
B4	B41	0.2	0.5	0.2	0.1
	B42	0.2	0.6	0.2	0
	B43	0.2	0.5	0.3	0
	B44	0.1	0.4	0.4	0.1

Evaluation Results. Take the median of each evaluation level to form the column vector S*=[90.5,79.5,70.0,40.5]T, then the formula for the comprehensive evaluation of each level of indicators is Si=WiS*, and the formula for the overall fuzzy comprehensive evaluation of the enterprise safety culture is S=WS*. Where Wi is the evaluation vector of each level of indicators and W is the overall evaluation vector.

Through the calculation, the enterprise safety culture level is 78.3, and the scores of each level of indicators are 77.7, 78.1, 78.7, 78.2. It can be seen that the construction of the safety culture of the enterprise is in the stage of independent management, and meets the basic requirements of the construction of the essential type.

3 Conclusion

Through the specific analysis of enterprise safety culture, this paper establishes four primary indicators and 16 secondary indicators for evaluating enterprise safety culture, establishes a hierarchical evaluation model of enterprise safety culture by using hierarchical analysis method, and solves the model, which results in the weight of each factor in the construction of enterprise safety culture, which basically reflects the focus in the construction of enterprise safety culture. The results of the model show that the construction of safety behavior culture (0.4309) is the first factor that affects the development of safety culture in enterprises, while the influence of safety concept culture (0.0963) comes last. Among all the secondary indicators, full safety incentive (0.4661), safety technology standardization (0.4173), and safety management behavior standardization (0.2576) are the three factors that have the greatest influence on the construction of safety culture in enterprises, and the safety promotion of enterprise platform (0.0909) has the least influence. From this result, it can be illustrated that in the construction process of enterprise safety culture, it is still necessary to play the subjective initiative of people, through the motivation and management of safety behavior of enterprise employees and constantly strengthen the standardization of safety technology to promote people to pay more attention to safety.

In order to further evaluate the indicators quantitative evaluation of the enterprise safety culture system, and then used a combination of hierarchical analysis and fuzzy evaluation of the level of enterprise safety culture construction method for evaluation, resulting in a safety culture score of 78.3 points, in the [75,85) this score range, said that the enterprise's overall construction of the essential safety culture is in the “self-management phase It is said that the overall construction of the enterprise's essential safety culture is in the “autonomous management stage”, the grade of the enterprise's safety culture is in the second level, and the recommended measures are continuous improvement. After comparative analysis, it is basically consistent with the actual situation of the enterprise, proving the effectiveness of the model.

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