Correlative Analysis of Occupational Health Management in Construction Companies to Related Factors Based on Fuzzy Clustering and Grey Theory

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Abstract. In recent years, China's construction industry has developed rapidly and become a pillar industry of the national economy, with a large number of construction practitioners. Occupational health management in construction industry is becoming more and more important. By means of risk identification and factor correlation, this paper studies various factors affecting occupational health management in construction enterprises, and ranks the importance of these factors. This is conducive to the construction enterprises to clarify the important and secondary factors affecting occupational health management, know which aspects can effectively improve the level of occupational safety management, so as to take targeted measures to make up for the shortcomings, improve the efficiency of occupational safety management, and ensure the occupational health and safety of construction personnel.

1. Introduction
Occupational health hazards in construction industry is extremely high. The product formation process of construction industry has the characteristics of high physical labor intensity, open-air production and poor working conditions. The health risk of construction workers is very significant. The occupational hazard factors involved in the construction industry are various and complex, covering almost all types of occupational hazard factors, such as dust (silica dust, cement dust, welding dust, asbestos dust), noise (mechanical noise, aerodynamic noise), high temperature, vibration, ultraviolet ray operation, ionizing radiation operation, high and low pressure operation, chemical poisons, etc. At present, a considerable number of construction workers work in harsh construction sites and are exposed to various toxic and harmful substances, and there are many risk factors affecting safety in the construction site, such as tower crane collapse and foundation pit collapse. It can be said that occupational safety management in construction industry is becoming increasingly important.

Especially, in recent years, China's construction industry has developed rapidly and become a pillar industry of the national economy. By the end of 2017, there were 88059 construction enterprises with construction activities in China, with 55.369 million employees and a large number of occupational health relations. Among them, the construction industry of migrant workers accounted for about one-third of the total number of migrant workers, accounting for more than 90% of the total number of construction workers.

Protecting the legitimate rights and interests of migrant workers is related to social stability and harmony. In recent years, the extensive production mode of construction industry is increasingly
unsuitable for the needs of employees to improve their work and development environment, which directly affects the stability of the industry and the sustainable and healthy development of the industry.

In order to enhance occupational health awareness and promote the legalization and standardization of occupational health protection, some developed countries have taken the lead in implementing occupational safety and health management system since the 1980s. In 1996, the American Industrial Health Association formulated the Guiding Document of Occupational Safety and Health Management System, and the United Kingdom promulgated the National Standard of Occupational Safety and Health Management System Guidelines. In 1997, Japan Industrial Safety and Health Association proposed Guidelines for Occupational Safety and Health, while New Zealand and Australia proposed the General Guidelines for Occupational Safety and Health Management System Principles, Systems and Support Technologies, Norwegian Classification Society has formulated the "Occupational Safety and Health Management System Certification Standards" and so on.

In the 21st century, some large construction enterprises in China began to introduce OHSAS (Occupational Health and Safety Assessment Series) standards and HSE (Health, Safety and Environment) management system. It can be said that the current occupational health management in China's construction industry has just begun to enter a real starting stage. And for most scholars, their research perspectives mainly focus on the occupational safety management, the occupational health research is only in a subordinate position.

In view of the above background, it is necessary to take the occupational health of construction industry as the research object, through risk identification, factor correlation and other technical means, study the various factors affecting the occupational health management of construction enterprises, and rank the importance of these factors. This is conducive to the construction enterprises to clarify the objectives of occupational health management, know which aspects can effectively improve the level of occupational safety management, so as to take targeted measures to make up for the shortcomings, improve the efficiency of occupational safety management, and ensure the occupational health and safety of construction personnel.

2. Analysis of the Influencing Factors of Occupational Health in Construction Industry

In reference to a large number of documents, and through the investigation and research of dozens of construction enterprises, it is determined that the following factors will have a significant impact on the professional construction management of the construction industry.

2.1 Daily management of enterprises
Including the publicity and education of occupational health work, the protective equipment and protective facilities, the protection of worker occupational health rights and interests, and the establishment of occupational health management organizations.

2.2 Enterprise decision-making
Enterprise decision-making. Including the guidelines of occupational health management of enterprises, the management's attention to the relevant laws and regulations of occupational health management, and the identification of hazard sources for construction site. For example, high temperature, vibration, dust, noise and chemistry.

2.3 Enterprise supervision systems
Including the formulation of emergency plans, the routine physical examination of workers, the inspection of the construction site, construction log management.

2.4 Workers' behavior and habits
It includes abiding by the rules and regulations of construction work, actively cooperating with the completion of management work, and participating in health management work as a master. For
example, before entering the construction site, workers can take the initiative to wear safety helmet, safety rope and other personal protective equipment.

2.5 Workers' consciousness
Including workers' understanding of occupational health-related knowledge, judgment of various risk factors on the construction site, and personal positive awareness of occupational health promotion.

2.6 Safety technology management
It mainly refers to the pre-job training for workers engaged in special types of work, including tower crane, crane, material hoist, construction power, scaffolding, external elevator, foundation pit support, formwork engineering. Only after examination, those workers can be officially on duty.

3. Fuzzy Clustering Analyses
The fuzzy clustering analyses are as follows.

3.1 Choosing statistics indexes
The domain X includes all the statistical objects, namely, \( X = [X_1, \ldots, X_r, \ldots X_m] \). where, \( X_{ik} \) is the kth attribute of \( X_i \), namely, \( X_i = [x_{i1}, \ldots, x_{im}, \ldots] \). In this paper, X is the set of all the factors affecting the public environmental awareness.

3.2 Data standardization
\[
x_{ik}' = \frac{x_{ik} - \bar{x}_k}{S_k}
\]
(1)

Where, \( \bar{x}_k \) is the average value of the kth attribute, \( S_k \) is the mean-square deviation of the kth attribute, namely
\[
\bar{x}_k = \frac{1}{m} \sum_{j=1}^{m} x_{ij}, S_k = \sqrt{\frac{1}{m} \sum (x_{ik} - \bar{x}_k)^2}
\]
(2)

Compress the standardization data into the scope of \([0, 1]\):
\[
x_{ik}^* = \frac{x_{ik}' - x_{i \min}^*}{x_{i \max}^* - x_{i \min}^*}
\]
(3)

Where, \( x_{ik}^* \) is the standardized numerical value of the kth attribute of the ith object after standardization: \( x_{i \min}^* = \min\{x_{1k}, \ldots, x_{ik}', \ldots, x_{nk}'\} \), \( x_{i \max}^* = \max\{x_{1k}, \ldots, x_{ik}', \ldots, x_{nk}'\} \).

3.3 Establishing the similar relation matrix
To construct the fuzzy relation matrix, namely, the similar relation matrix \( R = (r_{ij}) \), the similar degree \( r_{ij} \) between the classified objects must be calculated according to the standardized data of different factors. And \( r_{ij} \) is the similarity coefficient of the elements and , where \( 0 \leq r_{ij} \leq 1 \) (i, j = 1, 2, ..., n).

Determining \( r_{ij} \) using the absolute value deduction method
\[
r_{ij} = 1 - e^{\sum_{k=1}^{m} |x_{ik}^* - x_{jk}^*|}
\]
(4)

where, c can be properly selected which should make \( r_{ij} \) be in \([0, 1]\) and dispersed.
3.4 Calculating the transitive closure
Calculating the transitive closure \( t(R) \) of the fuzzy similarity matrix, then there have fuzzy equivalent matrix \( \tilde{R} = t(R) \). Using the square method to calculate \( t(R) \), for all \( k \in \mathbb{N} \), making \( R^{2k} \subseteq R^k \circ R^k \) (where, “\( \circ \)” is the product symbols of fuzzy operation), then \( t(R) = R^k \).

3.5 Fuzzy clustering analysis.
Three ways are usually applied to carry on the fuzzy clustering analysis, namely, netting clustering, maximum tree and fuzzy equivalence. In this paper we use fuzzy equivalence to carry on the fuzzy clustering. As for the fuzzy equivalence, the specific way is: to a different level of confidence \( \lambda \) (\( \lambda \) from 0 to 1), seeking matrix \( \tilde{R}_\lambda \).

\[
\tilde{R}_\lambda = (P_\lambda), P_\lambda = \begin{cases} 
0 & \lambda > r_{ij} \\
1 & \lambda \leq r_{ij}
\end{cases}
\]

(5)

Where, \( \lambda \) is the threshold value which can be selected according to actual needs.

4. Gray Correlative Analyses
The Gray correlative analyses are as follows.

4.1 Select a variable as a reference sequence
Select a variable as a reference sequence \( Y_0 = [y_0, y_0, \ldots, y_0, y_n] \) (n is the number of the selected reference period). According to the results of clustering analysis, the arithmetic average is selected on behalf of the group and constitute a new set of evaluation as a comparison sequence, then \( Y = [Y_1, Y_2, \ldots, Y_m]^T \) (m is the group number of fuzzy clustering analysis), resulting in

\[
\begin{bmatrix}
Y_0, Y_1, Y_2, \ldots, Y_m
\end{bmatrix} =
\begin{bmatrix}
y_0(1) & y_0(2) & \cdots & y_0(n) \\
y_1(1) & y_1(2) & \cdots & y_1(n) \\
\vdots & \vdots & \ddots & \vdots \\
y_m(1) & y_m(2) & \cdots & y_m(n)
\end{bmatrix}
\]

(6)

Where, \( Y_i \) is the data of each reference period of ith group, namely, \( Y_i = [y_i(1), y_i(2), \ldots, y_i(n)] \).

4.2 Nondimension analysis.
Nondimension analysis. The nondimension matrix:

\[
\begin{bmatrix}
Y'_{0}, Y'_1, Y'_2, \ldots, Y'_m
\end{bmatrix} =
\begin{bmatrix}
y'_0(1) & y'_0(2) & \cdots & y'_0(n) \\
y'_1(1) & y'_1(2) & \cdots & y'_1(n) \\
\vdots & \vdots & \ddots & \vdots \\
y'_m(1) & y'_m(2) & \cdots & y'_m(n)
\end{bmatrix}
\]

(7)

Where, \( Y'_i \) is the data of each reference period of ith group, namely, \( Y'_i = [y'_i(1), y'_i(2), \ldots, y'_i(n)] \).
4.3 Calculate the difference

Calculate the difference sequence, the two-pole smallest difference and the biggest difference, assume
\[ \Delta_k(k) = |y_i(k) - y_j(k)| \] (i = 1,2,⋯,m; k = 1,2,⋯,n), resulting in the difference matrix:

\[ \Delta = \begin{bmatrix}
\Delta_{01}(1) & \Delta_{01}(2) & \cdots & \Delta_{01}(n) \\
\Delta_{02}(1) & \Delta_{02}(2) & \cdots & \Delta_{02}(n) \\
\cdots & \cdots & \cdots & \cdots \\
\Delta_{mn}(1) & \Delta_{mn}(2) & \cdots & \Delta_{mn}(n)
\end{bmatrix} \tag{8}
\]

Then the two-pole smallest difference and the two-pole biggest difference are as follows:
\[ m = \min_i \left\{ \min_k \Delta_k(k) \right\}, \quad M = \max_i \left\{ \max_k \Delta_k(k) \right\}. \]

4.4 Calculate the correlative coefficient

The steps to calculate the correlative coefficient are as follows.

\[ r_{0i}(k) = \frac{m + \xi M}{\Delta_k(k) + \xi M} \] (i = 1,2,⋯,m; k = 1,2,⋯,n) \tag{9}

Where, \( \xi \in (0, 1) \), \( \xi \) is called recognition differential and usually taken as 0.5. Then the correlative coefficient matrix:

\[ r = \begin{bmatrix}
r_{01}(1) & r_{01}(2) & \cdots & r_{01}(n) \\
r_{02}(1) & r_{02}(2) & \cdots & r_{02}(n) \\
\cdots & \cdots & \cdots & \cdots \\
r_{mn}(1) & r_{mn}(2) & \cdots & r_{mn}(n)
\end{bmatrix} \tag{10}
\]

4.5 Calculate the weighted correlation degree

Using the average weight number method, then

\[ r_{0i} = \frac{1}{n} \sum_{k=1}^{n} r_{0i}(k) \] (i = 1,2,⋯,m) \tag{11}

Where, \( r_{0i} \) is the average correlative coefficient between the reference sequence and the ith group.

4.6 Sort

The bigger the value of \( r_{0i} \) is, it means that the more the ith factor influences the public environmental awareness and the more this factor should be considered. Assuming that the ordering is \( r_{01} > r_{02} > \cdots > r_{0m} \) after calculation, it expresses that the factors in the front, such as \( r_{01}, r_{02} \) should be highly emphasized when measures are taken to enhance the public environmental awareness; as for the factors in the end, such as \( r_{0m-1}, r_{0m} \),they do not play the decisive role to the public environmental awareness and may be due considered.

5. Discussion

\( R_1, R_2, R_3, R_4, R_5 \) and \( R_6 \) are used to express the influencing factors,that means daily management, decision-making, supervision system, behavioral habits, awareness department and safety technology.
management of enterprises. According to the above steps, the following conclusions are drawn: \( r_5 > r_6 > r_4 > r_1 > r_2 > r_3 \), which means that:

The factors affecting occupational health management in construction industry are ranked in order of importance: workers' awareness, safety and technology management, workers' behavior habits, daily management of enterprises, enterprise decision-making and enterprise supervision system.

It can be seen here that workers' awareness is the most critical link among all the influencing factors, and its effect on occupational health management is the most obvious. Therefore, construction enterprises must take measures to enhance workers' occupational safety awareness, help them to familiarize themselves with occupational health-related knowledge, learn to judge various risk factors on the construction site, and enhance personal positive awareness of occupational health.

Safety technology management is also important. Special construction workers must take part in safety technical training. They must pass the examination by the competent construction authorities and obtain the certificate of operation qualification for special construction work before they can take up their posts and engage in corresponding operations. Those undocumented technicians must be resolutely dismissed.

6. Conclusions

This paper introduces the fuzzy clustering analysis method and the gray correlative analysis method to accurately analyze the importance ordering of all the relevant factors affecting the occupational health management in construction industry. Accordingly, the main influencing factors can be considered especially when we establish measures so that all the adopted measures are focused and effective. Thus, the occupational health management in construction industry will be improved constantly and the occupational health and safety of construction personnel will be guaranteed.

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