Analysis on the Influence Relationship of Each Element in Intelligent Construction Site Based on DEMATEL-ISM

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Abstract. This paper deeply explores the mutual influence relationship between the components of smart construction site, and selects 16 practical application elements of smart construction site from three aspects of technical facilities, functional requirements and organizational management. The method of combining DEMATEL and ISM is used to find out the key factors and divide the hierarchical relationship, and analyze the mutual relationship between the components of smart construction site system. It provides basis and guidance for the development and application of smart construction sites.

Keywords: intelligent construction site · DEMATEL · ISM · System construction

1 Introduction

Based on the existing research, this paper analyzes and studies the system formed by the smart site from the perspective of the system. In order to better understand the smart site, this paper introduces the mathematical method to analyze the interaction between the various elements of the system, establishes the DEMATEL-ISM structure model, discusses the important factors of the construction of the smart site, and provides guidance and suggestions for the practical application of the smart site.

2 Research Methods and Technical Route

DEMATEL is a system analysis method that uses graph and matrix tools to analyze the influence relationship between elements, find out the key factors and simplify the system structure [1–4]. ISM can hierarchically divide elements with complex relationships and unclear structures by calculating the reachability matrix [5]. This paper will combine the two to analyze and study the safety production management system of smart construction site [6–8], and the technical route is shown in Fig. 1.

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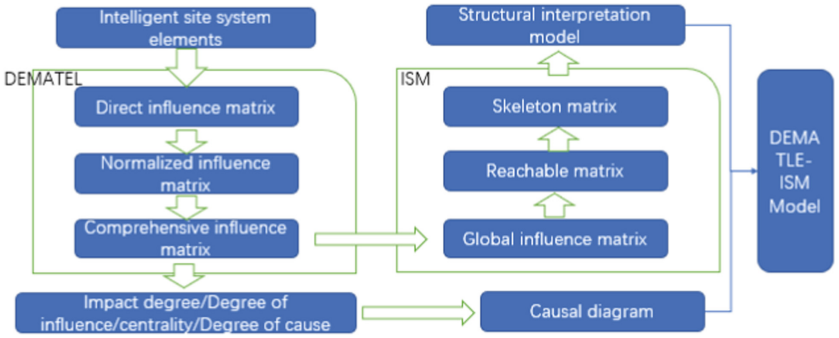

Fig. 1. Smart site system

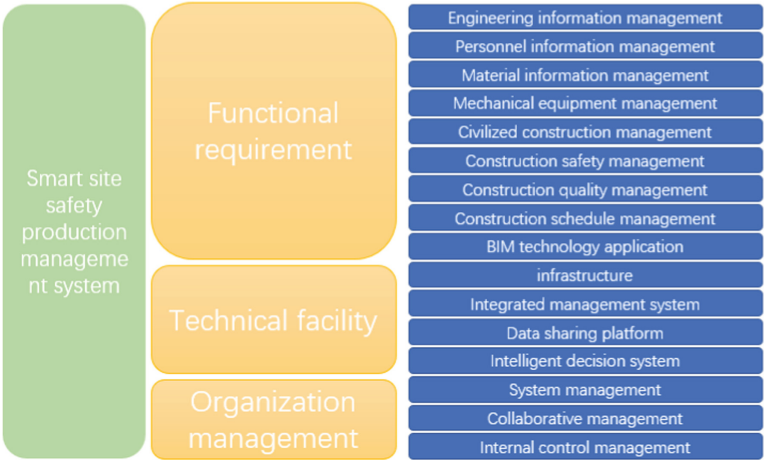

Fig. 2. Smart site system

3 Construction of DEMATEL-ISM Model

3.1 Element Identification

Through literature analysis, standard reference and case analysis, this study divides the smart site system into three categories, namely technical facilities, functional requirements and organizational management, with a total of 16 influencing factors [9], as shown in Fig. 2.

3.2 Model Construction

3.2.1 Determine the Direct Influence Matrix O

In order to study the relationship between various elements, data was collected through expert questionnaire survey, and experts in the field of construction engineering were invited to compare and judge and assign values. The direct influence matrix O was obtained, as shown in Table 1.

Table 1. It directly affects matrix O

0	0	0	0	0	1	1	2	0	0	0	0	0	0	3	0
0	0	0	0	0	3	1	2	0	0	0	0	0	0	1	0
0	0	0	0	2	0	2	2	1	0	0	0	0	0	1	0
0	0	0	0	1	2	2	1	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	1	1	1	1	2	0	0	0	0	0	0	0	0
3	3	3	3	2	2	2	2	3	0	1	1	1	1	1	2
3	3	3	3	1	2	1	2	3	0	0	0	1	1	3	1
3	2	2	2	1	1	1	2	2	0	0	0	0	1	3	1
3	2	2	2	2	2	2	3	2	0	0	0	0	1	0	1
2	2	2	1	1	1	0	2	2	0	0	0	0	0	2	0
1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	1	1	1	0	0	0

Table 2. Synthetic influence matrix T

0.000	0.000	0.000	0.000	0.000	0.033	0.033	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.000
0.000	0.000	0.000	0.000	0.000	0.100	0.033	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.000
0.000	0.000	0.000	0.000	0.067	0.000	0.067	0.067	0.033	0.000	0.000	0.000	0.000	0.000	0.033	0.000
0.000	0.000	0.000	0.000	0.033	0.067	0.067	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.033	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.067	0.000	0.033	0.033	0.033	0.033	0.033	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.100	0.100	0.100	0.100	0.067	0.067	0.067	0.067	0.100	0.000	0.033	0.033	0.033	0.033	0.033	0.067
0.100	0.100	0.100	0.100	0.033	0.067	0.033	0.067	0.100	0.000	0.000	0.000	0.033	0.033	0.100	0.033
0.100	0.067	0.067	0.067	0.033	0.033	0.033	0.067	0.067	0.000	0.000	0.000	0.000	0.033	0.100	0.033
0.100	0.067	0.067	0.067	0.067	0.067	0.067	0.100	0.067	0.000	0.000	0.000	0.000	0.033	0.000	0.033
0.067	0.067	0.067	0.033	0.033	0.033	0.000	0.067	0.067	0.000	0.000	0.000	0.000	0.000	0.067	0.000
0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.033	0.033	0.033	0.000	0.000	0.000

Table 3. DEMATEL calculated the result

element	Impact level D value	Impact level C value	Centrality D + C value	Reason degree D-C value (R)
A1	0.247	0.669	0.917	-0.422
A2	0.240	0.442	0.682	-0.202
A3	0.288	0.492	0.780	-0.203
A4	0.244	0.453	0.697	-0.210
A5	0.000	0.509	0.509	-0.509
A6	0.000	0.746	0.746	-0.746
A7	0.100	0.570	0.670	-0.470
A8	0.000	0.970	0.970	-0.970
A9	0.338	0.492	0.829	-0.154
A10	1.288	0.118	1.407	1.170
A11	1.113	0.077	1.189	1.036
A12	0.847	0.077	0.923	0.770
A13	0.872	0.113	0.985	0.760
A14	0.590	0.146	0.736	0.443
A15	0.108	0.642	0.750	-0.534
A16	0.423	0.183	0.607	0.240

3.2.2 Calculate the Synthesis Matrix T

The initial direct influence matrix O is normalized to obtain the normative influence matrix N. The specific calculation formula is shown in (1).

$$N = \frac{O}{\max(\sum_{j=1}^{n} o_{ij})} \tag{1}$$

Based on the above normalized matrix N, the comprehensive influence matrix T is calculated.

$$T = N(I - N)^{-1} \tag{2}$$

3.2.3 Calculate Impact Level Di, Impact Level Ci, Center Level Mi, and Cause Level Ri

$$D_i = \sum_{j=1}^{n} t_{ij}, i = 1, 2, 3 \ldots n \tag{3}$$

$$C_i = \sum_{j=1}^{n} t_{ij}, i = 1, 2, 3 \ldots n \tag{4}$$

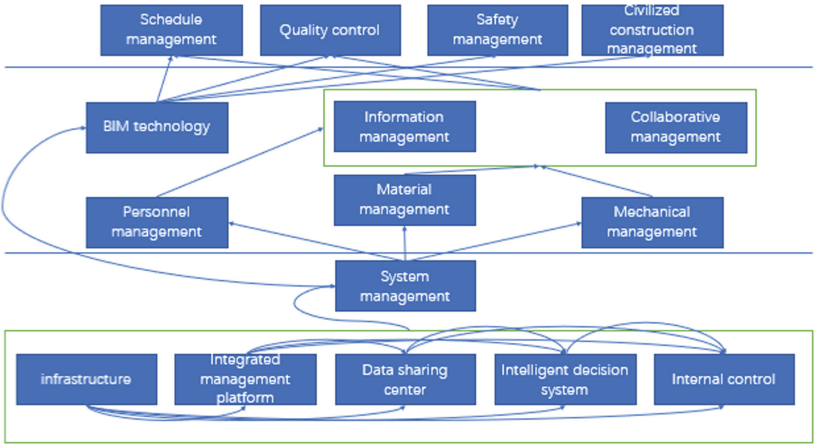

Fig. 3. Hierarchy diagram

$$M_i = D_i + C_i, i = 1, 2, 3, \ldots n \tag{5}$$

$$R_i = D_i - C_i, i = 1, 2, 3, \ldots n \tag{6}$$

According to the comprehensive influence matrix T, the influence degree and influence degree of each element are calculated by the formula.

3.2.4 Construct the Reachable Matrix

(1) Determine the global relation matrix Z.

In this study, relevant statistical data of the comprehensive influence matrix T is used to determine the threshold λ [10], whose mean value is x and standard deviation is σ, then $\lambda = x + \sigma$. Using MATLAB calculation, $x = 0.0262$, $\sigma = 0.0373$, $\lambda = 0.0635$. If $tij > \lambda$, then $Zij = 1$, if $tij < \lambda$, then $Zij = 0$.

(2) Calculate the reachable matrix R.

$$B = Z + I \tag{7}$$

3.2.5 Partition Hierarchy

The centrality of influencing factors of smart site was integrated into the ISM model to construct the DEMATEL-ISM model, as shown in the figure.

4 Conclusion

Based on the above analysis results, the key elements and relationship levels of the smart site system are finally obtained. Based on the model results, relevant factual opinions are proposed for construction enterprises and government management departments as follows:

(1) Expanding technological input.

Improve the attention of construction enterprises to informatization, increase the investment of technical resources, optimize supporting facilities, improve network transmission facilities, and establish informatization platform.

Government departments should strengthen information guidance, issue relevant incentive policies, encourage large, small and medium-sized enterprises to research and develop relevant software and hardware, encourage upstream and downstream enterprises to actively carry out information sharing and business cooperation, and promote the maturity of the smart market.

(2) Strengthen the talent reserve.

Strengthen the internal personnel training of construction enterprises, actively carry out technical knowledge education and practical skills training, formulate a reasonable assessment and incentive system, improve the technical application ability of personnel and enhance the enthusiasm of personnel to participate in the construction of smart site.

For government management departments, establish a talent exchange mechanism, encourage cross-enterprise and cross-regional cooperation and exchange, and organize relevant management and technical personnel to participate in learning and sharing experience.

(3) Improve the management mechanism.

For construction enterprises, they should strengthen the control and supervision of the whole process of the project and establish a self-evaluation mechanism to ensure the implementation of the basic management objectives.

For government management departments, a reasonable and efficient smart site supervision system and evaluation mechanism should be formulated to strengthen the comprehensive supervision and management of the implementation progress and effect of smart site projects. Promote the construction of industrial standards and technical norms for smart construction sites, speed up the improvement of laws and regulations, clarify technology-related legal responsibilities, and provide institutional guarantee for the smooth implementation of smart construction sites.

References

1. LUO JY. (2021) Evaluation of Green Supply chain Management Practice Based on Fuzzy DEMATEL Method [J]. New Economy, (09):66-71.
2. Wang L. (2021) Identification and Countermeasures of Sponge City Development Based on DEMATEL Method [J]. Green technology, 23(04):237-241.
3. Liu JK. (2018) Research on the Risk Factors of BIM Application in Construction Projects Based on DEMATEL Method [J]. Journal of Guangdong University of Technology, 35(03): 72-78.
4. Zhang SL. (2017) Analysis on Influencing Factors of Construction Safety Management Behavior Based on DEMATEL Method [J]. Safety and environmental engineering, 24(01): 121-125. DOI:https://doi.org/10.13578/j.cnki.issn.1671-1556.2017.01.021.
5. Wang CY. (2017) ISM modeling and analysis of Influencing Factors of Unsafe Behavior of Construction workers [J]. Journal of Hubei University of Technology, 32(01):37–40+108.
6. Zhao, XN. (2021) Research on Influencing Factors of Employee Green Behavior Based on Fuzzy DEMATEL-ISM Method [J]. Science and Technology Management Research, 41(05): 195-204.

7. Li, QN. (2022) Study on the Constraints and development path of Smart Site Construction in Gansu Province Based on DEMATEL-ISM [J]. Project management journal, 2022, 36(05):43-48.
8. Chen, WG.(2021) Study on the Influence Factors of urban disaster Resilience Based on DEMATEL-ISM [J]. Journal of Catastrophology, 36(01):1–6+17.
9. Xu YQ. (2019) Application of Internet of Things in safety control of smart construction site [J]. Construction Economy,40(12):101-106.
10. Sun, J. (2018) Research on DEMATEL Threshold Determination Method for Complex System [D]. Kunming University of Science and Technology.