

## Research and application of evaluation model of construction site layout plan based on information entropy

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**Abstract:** The layout plan of construction site is an important part of construction organization design, which is closely related to construction quality, safety, progress, cost, etc. In this paper, by analysing the content of the construction site layout plan, three evaluation indexes of construction cost, safety and environmental protection, and resource utilization are selected. According to the evaluation indexes, the evaluation model of information entropy is constructed, the weight function is determined, and the optimal layout plan is selected through comprehensive analysis.

### 1. Introduction

The layout plan of construction site is the main content of construction organization design, the basic guarantee of civilized construction and the important basis of construction preparation. Reasonable layout of construction site facilities can reduce the transportation distance of mechanical equipment in the site, reduce the transportation cost, protect the working environment of the construction site, provide the comfort of the operators, improve the enthusiasm of the operation, and speed up the construction progress; reasonable layout of construction site facilities should be flexible, which can be carried out with the progress of the project Proper adjustment.[5]

### 2. Contents of the layout plan of the construction site

The layout of the construction site is to divide the functional areas of the sites involved in the construction organization design, organize the horizontal and vertical traffic, and reasonably arrange the production and living sites, material stacking and processing sites of the construction site. [6]

#### 2.1. Layout of vertical transport machinery

Construction site of the material volume is larger, the construction hoisting machinery, such as tower crane, steel headframe, gantry, concrete pump arrangement of vertical transportation machinery such as the location of the materials, processing yard and warehouse storage station and the position of the internal transportation roads, water pipes have important influence, to the position of the priority arrangement of vertical transportation machinery.

#### 2.2. Layout of transportation roads

The road layout of the construction site should take into account to ensure smooth and safe operation of the transportation vehicles. If possible, the road on the site should be set as a ring to facilitate the transportation and rotation of the transportation vehicles and facilitate their direct transportation to the material storage yard.

#### 2.3. Layout of storage yard location and processing shed

According to the calculation, the area of the storage yard and processing shed of materials, components and semi-finished products is determined in advance, and then the specific location is

determined according to the construction stage, construction site and use time.

## **2.4. Layout of water and electricity pipe network**

In the construction site of the project, the water and electricity pipe network is the basic element to ensure the smooth progress of the project. Firstly, analyse the water and electricity usage in various places of the construction site, roughly determine the layout scope and direction of the pipeline, and then further analyse the quantity of water and electricity demand in various places, and then determine the main line and branch pipeline in the construction site.[3]

## **3. Select evaluation index**

### **3.1. The principle of evaluation index selection**

The objectives of project construction plane layout plan are multi-dimensional, mutual restriction and mutual influence, and it is difficult to put all the objectives into the evaluation model, so the evaluation index of the plan needs to be targeted screening, and the principle of scientific, representative and systematic selection should be followed. [1]

#### **3.1.1. The scientific**

Scientific is the most basic principle to select the influencing factors of site layout optimization. On the one hand, the evaluation indexes should comply with the relevant provisions of national laws and regulations and meet the requirements of standards and other aspects. On the other hand, the selection of the selected rating indicators should be considered comprehensively, including as many possible factors affecting the scheme as possible, so as to reflect the real situation on the spot more objectively.

#### **3.1.2. The representative**

According to the characteristics of the evaluation index, the evaluation index is divided into three categories: quantitative, qualitative and fuzzy. The selection indexes should be analysed according to the actual situation of the project site and the basic requirements of the construction unit for the layout of the project construction site, and the key factors of various indexes should be selected.

#### **3.1.3. The systemic**

The evaluation indexes should accord with the actual situation of the construction site, systematically analyse the mutual influence of indexes, and systematically analyse the internal relation and influence of various indexes, so as to make the evaluation comprehensive and complete.

### **3.2. Evaluation index of layout plan**

According to the basic principles that should be followed in the index screening, the construction cost, safety and environmental protection, resource utilization and other evaluation indicators are screened, among which the construction cost is the quantitative index and economic index, the safety and environmental protection is the qualitative index and management index, and the rationality of resource utilization is the technical index and fuzzy index.

#### **3.2.1. Evaluation index of construction cost**

Construction cost is an important index of site layout. Reasonably arrange material storage yard, processing shed and warehouse, plan transportation road and various pipeline lines, reduce transportation cost and storage cost, and further reduce the comprehensive cost of construction projects. [4]

#### **3.2.2. Evaluation index of safety factors**

Safety factor is an important factor to be considered in the layout of construction facilities. Facilities layout not only to do a good job dust, fire and other measures, but also to maintain a safe distance, so that the facilities comply with the relevant safety laws, regulations and other relevant

requirements.

### 3.2.3. Evaluation index of operating environment

The site construction layout should comply with the provisions of environmental protection laws, cement, fly ash and other dust materials should be closed management, construction waste water centralized precipitation treatment, reduce noise pollution, etc., provide a good operation environment for operators, effectively improve the work efficiency.

### 3.2.4. Evaluation index of resource utilization

In the layout of construction site facilities, on the premise of ensuring the smooth implementation of the project, the site should be occupied as little as possible, improve the utilization rate of the site, and further improve the overall utilization efficiency and construction efficiency of various materials and equipment resources.

## 4. Information entropy evaluation model of layout plan

The objectives of the construction site layout are multi-attribute and multi-dimensional, so the evaluation model of the construction site layout should take the multi-objective evaluation as the basic starting point, comprehensively analyse the mutual influence of various factors, and make a systematic, scientific and comprehensive evaluation.

Aiming at the systematic of evaluation work, a comprehensive evaluation model based on information entropy is constructed. The model can combine qualitative evaluation index with quantitative evaluation index to form a set of evaluation values that can comprehensively represent multi-index evaluation.

For “m” layout plans, “n” evaluation indexes are used to make comprehensive evaluation decisions. Let “ $x_{ik}$ ” be the predicted estimated value of plan “k” relative to the evaluation index “i”, and  $x^*_i$  be the expected value of the evaluation index. For positive indicators such as safety and environmental protection, resource rationality, the larger  $x^*_i$ , the better; For negative indicators such as construction cost, the smaller  $x^*_i$ , the better.[7]According to the definition of entropy, “n” evaluation indexes are used to calculate the entropy value “H” of “m” schemes, and the calculation formula is shown as 1.

$$H = -\sum_{i=1}^n \sum_{k=1}^m d_{ik} \ln d_{ik} \quad (1)$$

According to the uncertainty of the relative importance of the evaluation index to the evaluation of investment scheme, the entropy value is approximated. The two indexes of the evaluation entropy used to represent the entropy value of the evaluation value of degree evaluation are “i” and the indexes of the evaluation entropy used to represent the degree of important change of the evaluation value are  $e(d_i)$ . The calculation of  $e(d_i)$  is shown in formula 2.

$$e(d_i) = \frac{\sum_{i=1}^m \frac{d_{ik}}{d_i} \ln \frac{d_i}{d_{ik}}}{\ln(m)} \quad (2)$$

According to the property of entropy, the smaller  $e(d_i)$  is, the more important the evaluation index is. In order to make a comprehensive evaluation of the scheme, the evaluation weight  $\theta_i$  of the evaluation index was determined according to  $e(d_i)$ , as shown in formula 3.  $\theta_i$  represents the importance of the evaluation index to the plan of plane layout, which is determined by the relative importance of each evaluation index and the synthesis of its mechanism.

$$\theta_i = \frac{[1-e(d_i)]}{n-E} \quad (3)$$

In addition, uncertainty is an inevitable factor in project activities, and ambiguity and uncertainty have a general impact on the layout of project site. Another weight function “ $w_i$ ” is introduced, which represents the ability and practical experience of the construction manager to use the index of the weight function. The “ $w_i$ ” is measured and determined by the relative importance of each

evaluation index, and the specific determination methods can generally be brainstorming, Delphi method, etc. The objective evaluation weight function  $\theta_i$  and the subjective evaluation weight function “ $w_i$ ” are combined to form a comprehensive evaluation weight function “ $\lambda_i$ ”, as shown in formula 4.

$$\lambda_i = \frac{\theta_i w_i}{\sum_{i=1}^n \theta_i w_i} \quad (4)$$

For each plane layout plan, the weighted sum of “ $s_k$ ” of the difference between the closeness degree of all evaluation indexes and the expected closeness degree of the plan is shown in formula 5. According to the definition of “ $s_k$ ”, the scheme with a small value of “ $s_k$ ” is optimal. This eliminates the need for a comprehensive ranking of the application value and performance of the solution content. [2]

$$s_k = \frac{1}{M} - \sum_{i=1}^n \lambda_i d_{ik} \quad (5)$$

## 5. Case study

A residential project in Binzhou City, Shandong Province, has three residential buildings with a total construction area of 50000m<sup>2</sup> and a construction site area of 20000m<sup>2</sup>. By analyse the layout of vertical transportation machinery, site roads, stock yard, processing shed and water and electricity lines, the project department has designed four construction site layout plans.

Three evaluation indexes of project construction cost, safety, environmental protection and resource utilization were used to comprehensively evaluate four plane layout plans, and an information entropy model was constructed to optimize the plan. The actual predicted estimated values of each comprehensive evaluation statistical index of plane layout plan and their actual closeness are shown in table 1.

Table 1  $X_{ik}$  and  $D_{ik}$  information table for each layout plan

layout plan	Evaluation Index					
	The construction cost		Safety and environmental protection		Resource utilization	
	$x_{ik}$	$d_{ik}$	$x_{ik}$	$d_{ik}$	$x_{ik}$	$d_{ik}$
1	18	1	72	0.828	70	0.823
2	23	0.782	66	0.758	80	0.941
3	26	0.692	87	1	82	0.965
4	20	0.9	78	0.896	85	1
$d_i$	3.374		3.482		3.729	

The parameter data of information entropy model corresponding to the evaluation indexes of project construction cost, safety, environmental protection and resource utilization are calculated, as shown in table 2.

Table 2 Summary table of evaluation index parameters

Parameters	The construction cost	Safety and environmental protection	Resource utilization	Total
$e(d_i)$	0.855	0.858	0.860	2.573
$\theta_i$	0.339	0.332	0.329	1
$\omega_i$	0.35	0.40	0.25	1
$\lambda_i$	0.356	0.398	0.246	1

According to the evaluation data in the evaluation form, the index formula (5) can be used to calculate the closeness degree, weight and  $S_k$  of the evaluation index, and make a scientific optimization decision on the closeness degree and ranking of the project according to the evaluation results. The evaluation results of the layout plan of the construction site are shown in table 3.

Table 3 “ $S_k$ ” values and evaluation results of each layout plan

Layout plan	$S_k$	Rank	The construction cost	Safety and environmental protection	Resource utilization
1	0.27	4	18	72	70
2	0.212	3	23	66	80
3	0.111	2	26	87	82
4	0.091	1	20	78	85

By constructing the information entropy model, the comprehensive evaluation was carried out with the indexes of transportation cost, safety and environmental protection, site utilization, etc., and the  $S_k$  value of the fourth scheme was the minimum, which was determined to be the optimal scheme.

## 6. Conclusion

The plane layout of the construction site is a very systematic and comprehensive work, in the evaluation work should comprehensively consider the construction technology, construction schedule, the allocation of resources, construction environment, construction site safety and other influencing factors. By analysing the evaluation index of plane layout scheme, this paper constructs an evaluation model based on information entropy, comprehensively analyse the mutual influence of various factors, optimizes each scheme, and makes scientific and reasonable decisions.

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## References

- [1] Gong Xiaohu, Study on optimization of construction site facilities layout and evaluation of construction plan. East China jiaotong university, 2014.
- [2] Yang Huimin, Application of multilevel fuzzy comprehensive evaluation based on entropy weight. Journal of north China electric power university, Vol.32, No.5, pp.104-107, 2011.
- [3] Li Zhiyong, Lang Yiyong, Plane Layout method and key points of construction site. Shanxi Architecture, vol.37, no.28, 2011.
- [4] Song mingjian, Huang huijun, Principles of general layout planning and its influencing factors to be considered. Industrial architecture, vol.44, Supplement, pp.1198-1200, 2014.
- [5] Zhou Youhai, Gan Jielong, Layout and optimization of small construction site. China business community, no.38, pp.375-376, 2010.
- [6] Xiong Yongyao, On the rationality of construction plane layout. China new technology and new products, no.6, pp.108, 2012.
- [7] Qiu Wanhua, Management decision and applied entropy. Beijing: China Machine press, 2002, pp.140-143.