International Core Journal of Engineering Volume 11 Issue 5, 2025
ISSN: 2414-1895 DOI: 10.6919/ICJE.202505_11(5).0057

Analysis of Influencing Factors for the Layout of Prefabricated Building Construction Sites based on Bayesian Networks

Jiaen Chen[a]

School of Central South University of Forestry and Technology, Changsha 410000, China

[a]jsty12@163.com

Abstract

To enhance the scientific and rational layout of prefabricated building construction sites, this study is based on the Systematic Layout Planning (SLP) theory. Through logistics and non-logistics analysis, key factors influencing construction site layout are identified, and a Bayesian network model is constructed for reverse reasoning analysis of these factors. The research results indicate that when the construction site layout achieves a high level, the posterior probabilities of material flow, safety risks, and the convenience of prefabricated component hoisting increase significantly, suggesting that these factors have a substantial impact on site layout, while the influence of other factors is relatively minor. Based on diagnostic analysis, it is recommended to prioritize optimizing logistics paths, strengthening safety management, and improving hoisting efficiency in the planning of prefabricated building construction sites to enhance overall layout quality. This study provides a quantitative decision-making basis for the layout of prefabricated building construction sites, offering both theoretical and practical guidance.

Keywords

Prefabricated Building; Construction Site Layout; Bayesian Network; Influencing Factor Analysis.

1. Introduction

With the development of building industrialization, prefabricated buildings have been widely promoted in China due to their advantages such as fast construction speed, low resource consumption, and minimal environmental pollution. However, compared with traditional cast-in-place buildings, prefabricated construction imposes higher requirements on site layout, involving multiple critical processes such as transportation, storage, and hoisting of prefabricated components, making the layout more complex.

In the current research field of construction site layout planning, the Systematic Layout Planning (SLP) method is one of the most fundamental and critical theoretical approaches. Initially proposed by Richard Muther in 1969, its core lies in deeply analyzing resource flow within the construction site, precisely quantifying various flow relationships, and thereby solving layout challenges in a more scientific and systematic manner[1]. Scholars such as LAI wwwwW et al. conducted in-depth research based on SLP theory and innovatively established a mathematical model incorporating logistics intensity and adjacency intensity indicators to address construction site layout issues[2].However, existing studies primarily focus on traditional construction site layouts[3–4], while research addressing the unique characteristics of prefabricated buildings (e.g., transportation and hoisting requirements of prefabricated components) remains insufficient. Moreover, traditional methods struggle to quantify the influence relationships among various factors, whereas Bayesian

Volume 11 Issue 5, 2025
DOI: 10.6919/ICJE.202505_11(5).0057

networks can analyze dependencies between variables through probabilistic reasoning, providing a new research approach for optimizing construction site layouts[5].

This study integrates SLP theory with Bayesian network methodology to analyze key influencing factors in prefabricated building construction site layout, and identifies the most critical factors affecting layout quality through backward reasoning. The research findings can provide decision-making support for construction enterprises to optimize site layouts, thereby improving construction efficiency, reducing costs, and promoting intelligent development in prefabricated building construction management.

2. Work Unit Analysis based on Systematic Layout Planning (SLP) Theory

2.1 Logistics Relationship Analysis of Work Units in Prefabricated Construction

Due to the characteristic of prefabricated buildings having main components manufactured off-site and assembled on-site, logistics costs typically constitute a significant portion of overall construction costs in actual projects. Here, work unit logistics relationship analysis primarily refers to the transportation costs between work units required for construction activities, including logistics expenses generated by the movement or transportation of personnel, materials, and equipment. The following analysis examines logistics relationships between work units from three aspects: personnel, materials, and equipment.

During prefabricated building construction, personnel flow refers to the movement of construction workers between different work units. If the site layout of work units is unreasonable, workers may need to frequently move between units, which not only reduces construction efficiency but may also necessitate additional labor, thereby increasing overall project costs. Personnel flow can be quantified by measuring the relative distance between work units and the intensity of personnel movement.

Material transportation involves the movement of various construction materials (including prefabricated components) between work units. An improper site layout will increase material transportation costs, particularly return trip costs, thus raising total project expenses. The quantification of material flow similarly depends on the relative distance between work units and the intensity of material movement.

Similar to personnel flow and material transportation, equipment movement refers to the transfer of machinery between work units to meet transportation needs for both personnel and materials. Equipment flow metrics are likewise correlated with the relative distance between work units and the intensity of equipment movement.

2.2 Analysis of Non-Logistics Factors for Work Units in Prefabricated Construction

In previous site layout studies, many scholars have used safety risk factors as a substitute for non-logistics relationships between work units. However, in actual prefabricated construction processes involving prefabricated component placement and installation, the non-logistics relationships between work units are extremely complex and involve numerous construction management-related factors. Through field investigations and literature review, we have identified the following key factors for analyzing non-logistics relationships in prefabricated construction work units: safety risks, worker working environment, organizational management convenience, construction operation efficiency, project economic viability, convenience of prefabricated component hoisting, and site cleanliness. These factors play crucial roles in non-logistics relationships between work units and can significantly impact construction safety, efficiency, and cost control.Influencing Factors for Prefabricated Construction Site Layout

Based on the above analysis, the influencing factors for prefabricated construction site layout include:Logistics aspects: Personnel flow, material flow, equipment flowNon-logistics aspects: Safety risks, worker living environment, organizational management convenience, construction operation efficiency, project economic indicators, convenience of prefabricated component hoisting, and site cleanliness standards.The specific factors see Fig. 1.

 Volume 11 Issue 5, 2025
DOI: 10.6919/ICJE.202505_11(5).0057

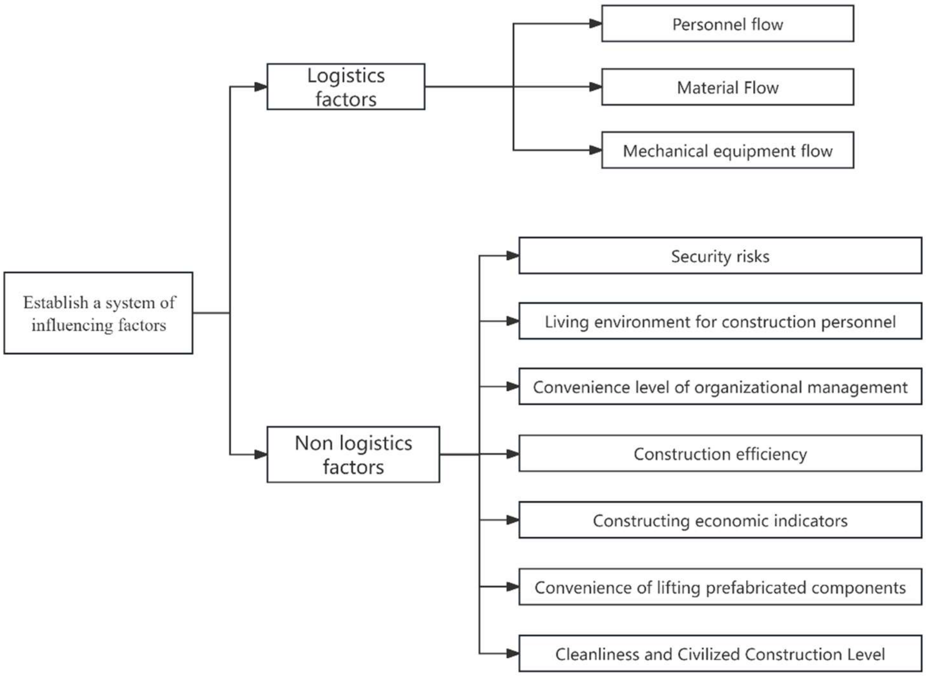

Fig. 1 Influencing Factors Structural Diagram

3. Bayesian Network Analysis

To conduct a comprehensive Bayesian network evaluation of prefabricated construction site layout planning, it is necessary to define the value ranges for both the overall site layout quality level and individual node performance levels to describe the state of layout quality. This study adopts a binary classification system to evaluate layout conditions: "high level" and "low level". The state "0" is defined as high quality, while "1" represents low quality. The value ranges for each node variable in the Bayesian network are specified ,see Table 1.

Table 1. Range of network node variable values

node	node name	range	
L	Level of venue layout	1	0
T	Logistics factors	1	0
T1	Personnel flow	1	0
T2	Material Flow	1	0
T3	Mechanical equipment flow	1	0
F	Non logistics factors	1	0
F1	Security risks	1	0
F2	Living environment for construction personnel	1	0
F3	Convenience level of organizational management	1	0
F4	Construction efficiency	1	0
F5	Constructing economic indicators	1	0
F6	Convenience of lifting prefabricated components	1	0
F7	Clean and civilized construction level	1	0

ISSN: 2414-1895 DOI: 10.6919/ICJE.202505_11(5).0057

To date, Bayesian network learning methods can be primarily categorized as follows:

The first approach involves constructing a scientific Bayesian network by determining its topological structure and specific parameter values based on extensive sample data. This method is suitable for networks with numerous variables but relatively low flexibility in complex structures.

The second approach relies on expert knowledge, where experienced professionals are invited through surveys or interviews to infer the network topology and estimate variable probabilities. This method is more appropriate for networks with fewer nodes and less complex relationships.

Given the limited historical data available for comprehensive evaluation of prefabricated construction sites and the inherent flexibility required in actual site layout planning, purely data-driven analysis may lead to deviations in practical engineering applications. Therefore, this study adopts a hybrid approach combining historical data analysis with expert judgment.

The Bayesian network visually represents dependencies between variables through a graphical structure. Its construction must satisfy the condition that nodes maintain conditionally independent relationships. Variables are not entirely independent but rather connected through causal parent-child node relationships. The sub-model contains no cyclic dependencies, and variables are not strongly connected components.

Typically, Bayesian network structures can be classified into three main types:

(1)HEAD-TO-HEAD Structure:

In this configuration, variables A and B independently influence variable C. When C is unknown, A and B remain independent.

(2)TAIL-TO-TAIL Structure:

Variables A and B are initially independent, but when variable C is known, it becomes a common influencing factor for both A and B.

(3)CHAIN Structure:

When C is known, variables A and B become conditionally independent, forming a causal chain with C.

A schematic representation of these structures is illustrated see Fig. 2.

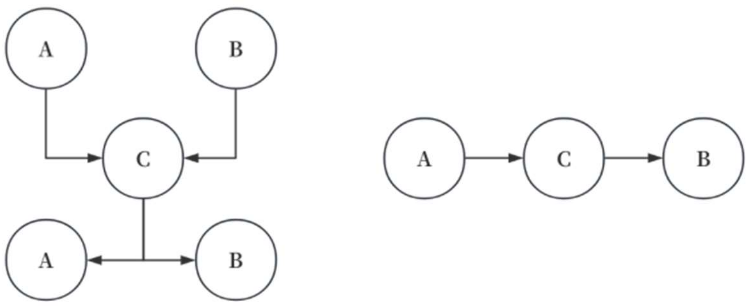

Fig. 2 Bayesian network architecture diagram

To obtain the numerical data required for Bayesian network analysis, this study engaged five professionals and experts specializing in prefabricated construction to evaluate the relative importance of:Logistics factors (T1-T3);Non-logistics factors (F1-F7)on prefabricated construction site layout planning.The GeNIe data analysis software was then employed to:Construct a Bayesian network evaluation model for prefabricated construction site layoutsPerform causal reasoning analysis.As shown in Figure 4.6, diagnostic inference analysis was conducted under the condition of 100% optimal site layout performance, revealing the probabilistic relationships between all influencing factors.see Fig. 3.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202505_11(5).0057

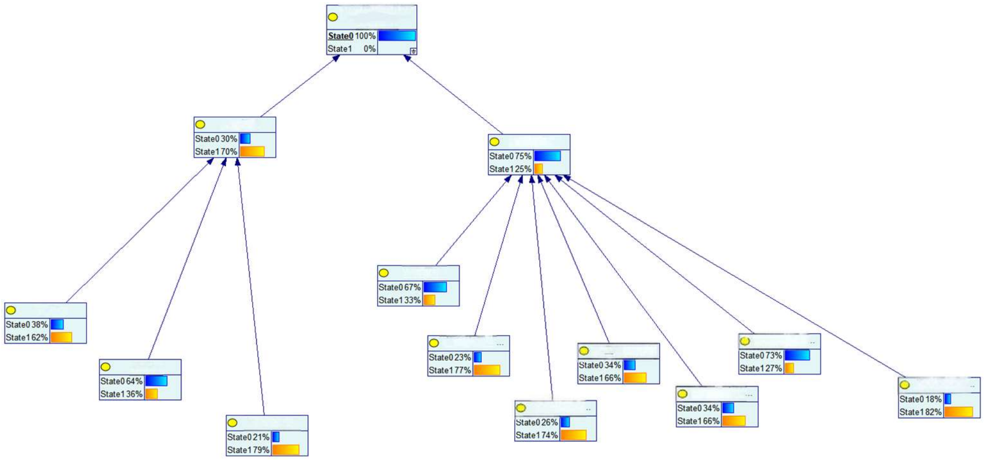

Fig. 3 Diagnostic analysis when the level of construction site layout is 100% high

4. Conclusion

Diagnostic analysis reveals that when prefabricated construction site layouts achieve high performance levels, the posterior probabilities of material flow, safety risks, and prefabricated component hoisting efficiency are significantly elevated. Reverse reasoning confirms these factors exert substantial influence on site layout optimization. In contrast, other metrics demonstrate relatively minor impacts on layout configuration.

References

[1] MUTHER R. Long range planning of industrial facilities [J]. Long Range Planning, 1969, 2(2): 58-60.

[2] LAI W, FU Y, LI R, et al. Optimum Design of Construction Site Layout Based on SLP Method and Genetic Algorithm; proceedings of the InternationalConference on Construction and Real Estate Management 2020, F, 2020 [C].

[3] TAO G, FENG H, FENG J, et al. Dynamic Multi-objective Construction Site Layout Planning Based on BIM [J]. KSCE Journal of Civil Engineering, 2022, 26(4): 1522-34.

[4] MONTEIRO A. A Hybrid Framework for Multi-Objective Construction Site Layout Optimization [J]. Buildings, 2024, 14.

[5] WANG L. Facilitating Circular Transition in the Construction Industry: Optimizing a Prefabricated Construction Site Layout Using a Novel BIM-Integrated SLP-GA Model [J]. Buildings, 2024, 14.