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Site Layout Optimization and its Impact on the Cost of Construction Projects

Mohammad Javad Taheri Amiri[1,*] , Milad Hematian[2], Farshidreza Haghighi[3], Maedeh Javaheri Barforooshi[4]

[1] Department of civil engineering, Higher Education Institute of Pardisan, Mazandaran, Iran
[2] Department of industrial engineering, Mazandaran University of Science and Technology, Babol, Iran
[3] Department of civil engineering,Babol University of Technology, Babol, Iran
[4] Department of civil engineering,Islamic Azad University of Arak, Arak, Iran

ABSTRACT: The dynamic site layout is identifying the optimum location for temporary equipment, materials, and other available tools and offices at construction sites. The Site layout is classified as a dynamic problem because the necessary equipment is changed continuously during the project lifetime. Some research investigated this issue in recent years and tried to develop various algorithms to solve such problems due to its complexity. In this study, a linear programming model is proposed to minimize total transportation cost among different parts, relocation cost for the moveable facility, and transportation cost between the warehouse and other parts. An invasive weed optimization algorithm is developed to solve large-scale problems. Computational results show that different layout is obtained based on priorities considered for each part so that their layout can be changed if priority is varied. To validate the proposed algorithm, its results for the small-scale problem are compared with results obtained from solving it in GAMS software. Results obtained from the proposed algorithm for small problems reveal that they are so close to obtained from the exact method. Furthermore, scenario analysis indicates that the proposed metaheuristic algorithm is outperformed, thus the proposed IWO algorithm can be applied for solving the large-scale problem in the real world.

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1. INTRODUCTION

The site layout is to determine the temporary and permanent tools, machines, and facilities for performing technical and operational operations and appropriate space allocation among them to achieve the project goals. Construction sits layout design means arranging the temporary facilities required within the specific boundaries of a site. The main task of optimizing this process is to achieve an arrangement of temporary facilities that meet the goals of managers. Generally, construction site equipment is a complex issue due to uncertainties in decision making and it depends on various factors. One of the important factors in the efficiency of construction projects is the proper site layout [1]. It should be noted that by spending a short time designing the facility location and spaces before they are installed, many changes and inconveniences can be prevented. Researchers are looking for innovative algorithms and models that provide a good solution to arrange equipment [2]. Today, the growth of project complexity relying on personal experience and knowledge does not meet the needs of the problem, and therefore, scientific and metaheuristic methods have been developed to solve such problems. The proper site layout cause reduces transportation cost and project execution cost, increase safety and construction efficiency [3]. A construction project is affected by its unique features and characteristics, variables and uncertainties, various internal and external factors affecting the project, size, and shape of the site [4]. The purpose of the construction site layout is to identify temporary and necessary equipment for various construction operations, site shape, and size, and finally, place them in the optimal location inside or around the site [5]. The site layout only in terms of transportation cost reduction leads to the compact arrangement of facilities, while the proximity among them increases the likelihood of an accident. Site layout includes the cost that covers a large part of the construction project economics. The first step in site layout is to identify and select the temporary equipment and facilities that due to the abundance of various factors in this field, appropriate decision criteria recognition is felt. Therefore, in this study, the construction site layout has been optimized by minimizing project costs.

2. RESULTS AND DISCUSSION

As mentioned above, the site layout problem is studied using wee invasive optimization algorithm. To do this end, a

*Corresponding author's email: jvd.taheri@gmail.com

mathematical model is proposed to minimize transportation cost, relocation cost, and distance from warehouse. Then, a case study is applied to validate the proposed model. The required data are collected from the case described. The facilities are divided into stable and moveable ones. The facilities include an operational zone, open and covered warehouse, fuel tanks, construction and assembly site, tower crane, and batching. After implementing the IWO algorithm in MATLAB software, parameters setting are done. In this study, three scenarios are considered to analyze the proposed model. They are designed based on the position of facilities. Furthermore, it is assumed that the tower crane has risk according to the safety aspect. The minimum and maximum distance from the tower crane are considered in scenarios. To validate the proposed metaheuristic algorithm, the mathematical programming model is solved exactly by GAMS software. To simplify the solution to the problem, the angles in the proposed model have been omitted. Comparison between results obtained from two exact and metaheuristic approaches indicates that they are almost the same. Therefore, it can say that the proposed algorithm has enough accuracy to solve problems on large scale.

3. CONCLUSION

In this study, the site layout problem in a construction project has been investigated. There are two types of stable and moveable equipment so that there is the ability to change moveable equipment position in different periods. The aim is to minimize transportation, relocation, and distance cost between facilities and warehouses. To solve the proposed problem, a linear programming model is developed. Moreover, an IWO algorithm is developed to solve the problem on large scale. A construction site in Babolsar is considered a case study. To facilitate the site, five stable equipment and two moveable one is considered. Three scenarios that are different based on the distance between facilities are considered to analyze the proposed model. The results show that the proposed algorithm can be used to solve a large problem in reality. All designers, organizations, government agencies, companies, and private sectors related to construction projects can be used from the obtained results to optimize the site layout, improve economic management and reduce costs in the implementation of projects to economic and managerial growth. However, other goals such as workforce safety can be considered for future research. Also, the orthogonal distance can be applied to calculate the distances among facilities. Finally, some other constraints related to tower cranes can be investigated in future work.

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