Solving the problem of locating construction sites based on a combination of weeding algorithm and forbidden search algorithm

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In this research, the problem of locating construction sites was solved based on a combination of the weed algorithm and the forbidden search algorithm. The research problem was considered in a dynamic mode and optimized based on the location of the layout and cost. For this purpose, two categories of fixed and mobile equipment were considered so that the capacity of moving equipment was considered in different intervals of the project planning horizon. To solve the research problem in large and real dimensions with dynamic conditions, a combination of the weed algorithm and the forbidden search algorithm was used. The method of allocating and arranging equipment in three stages for each of the solutions in each stage is presented below. The problem was solved in ten iterations in the GAMS software for the weed algorithm and the forbidden search algorithm to determine the optimal locations based on factors such as accessibility and size of equipment, tower stability, cost, ease of servicing different sections, and safety of the workshop environment.

KEYWORDS: Construction site location problem, weed algorithm, forbidden search algorithm.

1- Introduction

The problem of construction site layout planning (CSLP) plays a crucial role in project cost, safety, accessibility, and efficiency [1]. Improper allocation of fixed and mobile facilities may lead to excessive transportation costs, safety hazards, and inefficient workflow [2]. Previous studies mainly considered static layouts and neglected the dynamic nature of construction projects. To address these limitations, the present research proposes a hybrid approach based on the Invasive Weed Optimization (IWO) algorithm combined with the Tabu Search (TS) algorithm. This combination enables the minimization of relocation costs, transportation efforts, and unnecessary re-allocations of site facilities [3, 4].

2. Research Methodology

The study models CSLP as a Quadratic Assignment Problem (QAP), where a set of facilities (n) must be allocated to a set of locations (m) under multiple constraints. Two types of equipment were considered: fixed (permanent) and mobile (relocatable). The IWO algorithm, inspired by the natural growth process of weeds, was employed to explore the global search space and minimize redundant handling of materials and facilities. [5, 6].

3. Case Study and Data

The dataset of Lacksonen and Enscore [7] was adopted, including test problems with 6, 12, 20, and 30 facilities (N = 6, 12, 20, 30) over 3 and 5 planning periods (T = 3, 5). A total of 32 test instances were solved. Seven facilities were considered in the construction site, such as site office (f1), control room (f2), warehouse (f3), residence (f4), tower crane (f5), batching plant (f6), and steel workshop (f7). Table 1 presents the specifications of site equipment, including fixed and variable relocation costs, as well as their geometrical dimensions.

Table 1: Site equipment specifications

Symbols	Site equipment
f1	Site office
f2	Control room for electricity, water and other facilities
f3	Warehouse
f4	Workers' residence
f5	Reinforcing steel workshop
f6	Tower crane
f7	Concrete and batching workshop

4. Results and Discussion

Computational experiments were carried out using GAMS software with 10 independent runs for each algorithm. Results indicated that the hybrid IWO–TS algorithm significantly reduced relocation and transportation costs. For example, using IWO, the cost decreased from 1.99 × 10^3 USD to 1.89 × 10^3 USD, while TS reduced the cost from 1.99 × 10^3 USD to 1.93 × 10^3 USD. The convergence of results confirmed the robustness of the hybrid method. Figures 1 illustrate the optimal cost reductions obtained using IWO and TS, while Figures 2 demonstrate the optimal layout of facilities at different project stages. It was observed that the warehouse (f3) remained the central fixed facility, and the layout of other facilities was dynamically adjusted based on minimum and maximum distance constraints.

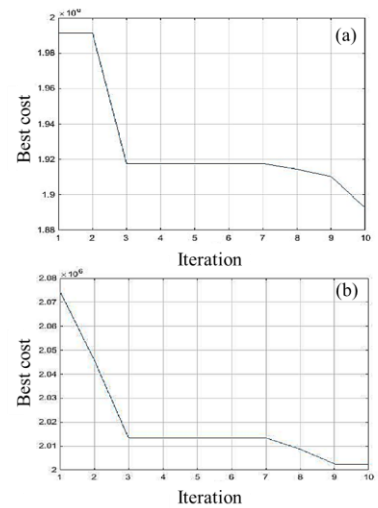

Fig. 1: Results of the optimal response for cost; (a): the weed algorithm, (b): forbidden search algorithm

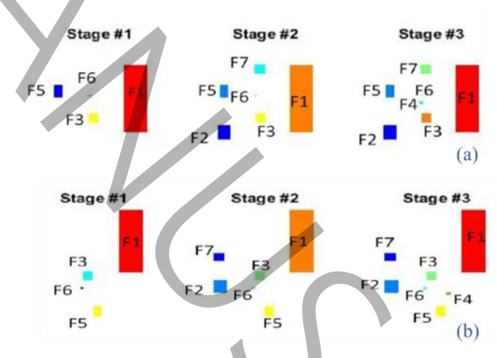

Fig. 2: Location of site equipment layout based on the results; (a): the weed algorithm, (b): forbidden search algorithm

5. Conclusion

This research addressed the dynamic CSLP using a hybrid metaheuristic combining IWO and TS. The results demonstrated that the proposed model effectively reduces relocation and transportation costs, while ensuring accessibility, safety, and operational efficiency. Both algorithms achieved feasible layouts; however, IWO showed slightly better performance in minimizing total costs.

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