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# IMPACT OF CONSTRUCTION SITE LAYOUT PLANNING OPTIMIZATION ON CONSTRUCTION PROJECT MANAGEMENT (CASE STUDY OF LAUNCHER/ RECEIVER STATIONS IN PIPELINE PROJECTS IN KHORASAN PROVINCE)

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## ABSTRACT

One of the important factors in the efficiency of construction operations is the proper replacement construction projects of the construction site layout planning (CSLP). That this would not be possible without oversight of the factors affecting it. Therefore, the study of factors affecting the replacement of construction site layout is considered vital in projects. Different factors are involved in the replacement of CSLP, which examine the economic dimension and the effects of changing costs and time during work. Due to the complexity of the subject, it is solved using hyper-innovative algorithms. This research is a linear programming model for optimizing the layout of equipment for Launcher/Receiver (L/R) stations. Due to the complexity of the problem, the invasive weed algorithm was used to achieve an optimal response. The goal is to minimize the total costs associated with transportation, relocation and relocation, and changes during implementation. The results of the calculations and output of the algorithm showed the variation of the answer in the optimal layout of the CSLP, which was obtained at the lowest distance and the most optimal mode. The results were presented in a similar scenario in the projects.

**Kewords:** IWO algorithm, Launcher/Receiver (L/R) stations, construction site layout planning (CSLP) optimization, change management, cost management.

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## 1. INTRODUCTION

Since construction has a non-monotonous nature, each project requires a special animation program. Due to variables and uncertainties, web design is a problem with different angles. With the growing development of industry, more facilities and equipment have been invented and built in industries, construction and construction works, resulting in these new and advanced facilities and equipment, allowing the implementation of large and more complex projects .The importance of this issue is more evident in industrial and construction projects. The substitution in each CSLP is determined by the dimensions, sensitivity and amount of equipment. Internal animation on sites also makes sense based on equipment, buildings, facilities and machinery. The main task of optimizing this process is to achieve a layout of temporary facilities that meet the designers ' objectives. Construction site layout replacement and optimization one of the most important factors in project management knowledge and project success factors has been identified.

Lork *et al*. [1] examined the organizational knowledge and project management organs in the success of oil and gas projects from the perspective of stakeholders and the integrity and skill of the project team in 2022. Identifying project management components and components is very effective in the success of researchers.

In general, equipping CSLP is a complex issue due to the uncertainties in decision-making and depends on several factors. One of the important factors in the efficiency of construction operations of construction projects is the proper replacement of the CSLP [2]. It should be noted that by taking a short time to design the layout of equipment and spaces before deploying them, many damages and discontent can be avoided. Of course, moving and changing the layout of spaces and equipment on paper is much easier and less expensive than actually moving them. For this reason, researchers are looking for hyper-innovative algorithms and models that will give a good answer on how to arrange equipment and Units [3]. Today, as construction and industrial projects get bigger and more complex, relying on personal experience and knowledge does not meet the need for the problem, and therefore the use of scientific and hyper-innovative methods in solving such problems has been developed. The correct replacement of equipment in CSLP will reduce the cost of transferring materials, reduce the time of project implementation, increase the safety and health of workers and engineers and improve construction efficiency [4].

One of the definitions proposed for the replacement states that the purpose of the replacement of CSLP is to identify select and specify the necessary and necessary temporary equipment and equipment for various construction operations specify their size shape and dimensions and finally place them in the optimal place inside or around the CSLP at the time of the project [5]. Rouhparvar and Ravanshadnia, looked at the issue of designing the CSLP equipment, focusing on determining the dimensions of the facility and the relationships between them. In this study, three of the four stages of the design of the CSLP equipment layout were proposed and focused on the third step, namely determining the size and shape of the common facilities available in the CSLP equipment to achieve maximum efficiency [6]. Mahmoudabadi *et al*. [7] discussed the issue of optimizing the layout and deployment of equipment in CSLP. In this regard, a harmony search algorithm has been developed to solve the proposed problem.

Asadzadeh and Gholipour presented an algorithm for optimizing the layout of hazardous



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equipment on the CSLP to achieve maximum safety. In this regard, mathematical algorithms have been used instead of common exploration algorithms in order to optimize the problem of replacement of CSLP equipment, which with high confidence makes it possible to achieve the most optimal layout. The aim of this study is to minimize the total risk to the facility located on CSLP. They studied the issue of optimizing the replacement of facilities under the influence of Crane risk on the CSLP in view of the safety discussion. The aim of this study is to minimize the total risk to the facilities located on the CSLP from the cranes. Mathematical algorithms have been used to optimize the layout problem instead of common exploration algorithms in solving CSLP problems [8]. Andayesh and Sadeghpour examined the time dimension in the CSLP and examined the differences between static and dynamic models. The dynamic method presented in the studies also varies in nature, and as a result, the responses presented in them differ from each other. Some researchers divide the project time into different time frames and replace the equipment in these frames, called phased dynamics [9]. Huwang and Wang designed an optimal site layout taking into account safety considerations. A mixed integer linear programming model has been developed for this purpose. The branch and Crane algorithm and LINGO software were used to solve the problem. The aim of this study is to minimize the total cost, including the cost of transporting materials, the cost of preparation and re-location. Hamad & et al., developed a multi-purpose mixed integer nonlinear programming model for site layout design. The aim of the study has been to minimize transportation costs and noise pollution. A Pareto answer set is provided for the case study used [10]. Ning *et al*. [11] developed a multi-criteria model for the construction site layout problem using fuzzy logic. In this regard, goals such as security and foreign transport have been considered. To solve the multi-criteria problem, the topsis method has been used. Papadaki and Chaciacos, developed a multi-target site layout model using a genetic algorithm. The objectives of this study include construction costs, transportation costs and safety. The results showed that the proposed genetic algorithm was functioning properly [12]. Yi *et al*. [13] developed a mathematical planning model for the construction site layout problem. Safety, health and environmental factors such as dust and noise are considered in this model. Computational results have shown that the proposed model has achieved up to 20% improvement in achieving optimal response. Ning *et al*. [14] presented a quantitative safety risk assessment model for the issue of building site interior layout design. Risk factors include the risks of falling objects, noise pollution, and chemicals. In this study, risk factors are first identified and categorized. Then they were analyzed and evaluated. A case study has also been submitted for the validation of the proposed model. Ning *et al*. [15] developed a three-target ant colony optimization algorithm for the safe design of the construction site layout. In addition to designing safety-related goals, the study also tried to minimize costs. A case study was also used to validate the proposed model. During the study of Kaveh and Rastegar Moghaddam [16], a combined WOA-CBO algorithm was presented for the planning problem of the construction site layout. The CSLP method and how this arrangement is very important in construction projects and directly affects time and cost. By reducing time and cost and improving safety, this goal must be achieved . The study proposed an attempt to enhance WOA's structure by hybridizing it in some concepts of particle collision optimization (CBO) in order to improve solutions, reliability, and speed of convergence in the new method, called the WOA-CBO algorithm, which aims to optimize CSLP in construction projects.



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Khodabandelou and Park [17], studied agent-based modeling and simulation in construction. Agent-based modeling (ABM) has gained popularity in construction research due to its unique system modeling features and recent advances in computing capabilities, which led to significant growth in the issue of publication on ABM construction research. A case study was considered to validate the practicality of the model designed in addressing CSLP-CMLP and CSLP-SP interactions. This research helped the body of knowledge by familiarizing researchers with ABM in the framework of construction from a specific perspective: (I) a theoretical perspective; and, (II) a practical perspective by examining industry-oriented studies and making recommendations to enhance its practicality in real construction. During the Song *et al*. [18] reviews, modeled the effect of multi-stakeholder interactions in the planning and construction of the site layout using factor-based decentralized optimization. Review was the overall goal of CSLP-CMLP / SP integration optimization. In this study, taking into account the target function, the cost is minimized and one of its main limitations is the proper layout of the CSLP policy, which in this regard considered 5 main components for the target function.

Choi *et al*. [19] an automated decision-making model for the optimal noise (sound) design of the dam in terms of health impact, productivity, and cost aspects, presented a model developed to improve the urban acoustic environment that ensures the profitability of construction companies and is used in construction projects using mathematical calculations and using three objective functions in business and with feasibility in the case study examined. In fact, the internal layout of the CSLP only from the point of view of reducing the cost of transportation and changes, brings us to a mass and dense layout of the CSLP equipment and facilities, but the proximity between the equipment increases the likelihood of an accident [20]. The interior layout plan of the CSLP includes a cost that covers a large part of the CSLP project economy. The first step in the internal layout of the CSLP is to identify and select temporary equipment and facilities, which are felt due to the abundance of various factors in this field, the need to know the appropriate decision criteria. The replacement of construction and industrial CSLP is part of the process of the CSLP equipping plan and covers a large part of the project economy. Therefore, the research focuses on optimizing the internal CSLP with its importance in industries by minimizing project costs.

Typically, hyper-innovative algorithms are used in these problems due to the complexity of the problem and its large dimensions. Based on the review of various articles, it is clear that most articles use the method of optimizing the genetic algorithm to model this problem. In this study, the invasive weed optimization method, which is one of the most powerful optimization methods, was used to optimize the optimized layout model of the CSLP. In most studies, the objectives include minimizing the cost of deployment, transportation, rearrangement and safety. In previous studies, the distance between equipment, especially in specific equipment, has played a key role, and the connection of other equipment, which is directly related to this distance and is of great importance in terms of cost, has not been introduced, especially in oil and gas projects. One of the equipment that can operate with other equipment inside a receiving station and an important transmitting station is the launcher and receiver equipment. Therefore, in this study, the goal is to minimize the cost of the distance traveled & changes between the L/R and other equipments.



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## 2. RESEARCH METHOD

The Invasive Weed Optimization algorithm, or IWO, is a numerical optimization algorithm inspired by weed growth. The algorithm was proposed in 2006 by Mehrabian & Lucas [21]. Weeds are plants whose aggressive growth is an important threat to agricultural plants. Weeds are very stable and adaptable to environmental changes. So by drawing inspiration and simulating their properties, a strong optimization algorithm can be reached.

Weeds are plants that grow globally and prominently in a specific geographical area, so that they cannot be removed and controlled by humans. One claim about weeds is that weeds always win. In general, the reasons for this claim can be expressed as: (i) The presence of weeds after thousands of years of farming; (ii) The presence of weeds even after the use of various toxins; (iii) the emergence of new species of weeds on the ground.

The above features indicate that weeds are strong and annoying plants in agriculture. It also reflects the fact that weeds adapt themselves to the environment and change their behavior to grow. The success of weeds is dependent on their ecology and biology [21].

### *2.1. Simulation of invasive weed behavior*

The steps to simulate weed behavior include:

Step 1: spread the seeds in the desired space.

Step 2: grow seeds according to the desirability of the birth and environmental dispersion.

Step 3: the continuation of grass life with greater desirability Competitive Elimination

Step 4**:** continue the process until you reach the best plants.

The flowchart on how weeds work is shown in Fig. 1.

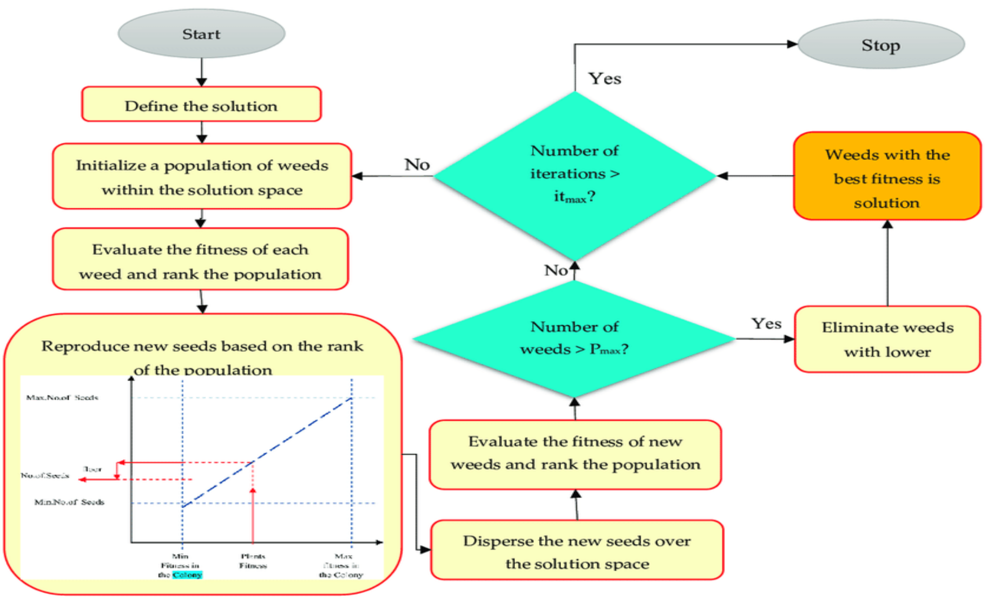


Figure 1. Weed Algorithm Flowchart [21]

*2.2. Input parameters of weeds*

Input parameters considered for the proposed weed algorithm of this research are listed in Table 1. The study considered two conditions of cessation. Condition one: the difference in the value of the target function is the sum of the substitution costs. Condition two: the number of repetitions. The number of iterations in this algorithm is considered equal to 120.

Table 1. input parameters of the research

| | | |
|---|---|---|
| Primary population numbers | NO | 25 |
| Maximum number of populations | Pmax | 30 |
| Minimum number of seeds | Smin | 0 |
| Maximum number of seeds | Smax | 5 |
| Initial value of standard deviation | Sigma_Init | 3 |
| The final value of the standard deviation | Sigma_Final | 0.001 |
| Number of repetitions | Itmax | 120 |

*2.3. Research method*

The final goal of this research is to optimize the internal replacement of the site of construction and industrial CSLP, which seeks to reduce the cost of the replacement of the site. According to the literature of the subject and numerous reviews it was found that the optimization of this research is of the single purpose type which aims to minimize the total cost of substitution of CSLP,It was made. Another point in this issue is the limitation of the presentation of the pre-determined replacement program by the project management. Because the CSLP is constantly changing and evolving during the project period, and materials and equipment are continuously entering and leaving it during the project period, and at each stage of construction, the equipment and machinery required change according to the project priorities, and contractors decide on this day by day or each period according to the conditions of the CSLP, leading to the intersection of spaces with each other and the equipment not being in place and thus frequent shifts in the project. Therefore, the search for a suitable equipment replacement optimization method for equipping construction and installation CSLP has been the focus of numerous researchers, who have used a single-target mathematical model with the invasive weed meta-innovative algorithm method to solve this problem.

This section presents the mathematical model of the problem with the parameters and variables of the problem. It should be noted that in order to simplify the proposed model, the considered costs are considered independent of time.

Various criteria affect the placement of the tower crane, including the distance between them and the safety considered 4 the relationship is used in this study, which is mentioned below [22]:

(1) $Min\ TC + RC + DC$: The minimum set of shipping costs, the cost of changes and the cost of moving up to the launcher or receiver shown with TC, RC and DC respectively.

(2) $TC = \sum_{t=1}^{T} \sum_{i=1}^{F_{t-1}} \sum_{j=i+1}^{F_t} TCR_{ij}^t D_{ij}^t$: Represents the set of equipment travel costs at different stages. $TCR_{ij}^t$ is the amount of travel cost between facilities i and j in Phase t and



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$D_{ij}^{t}$ is the orthogonal distance between facilities i and j and $F_t$ expresses the number of fixed and mobile facilities in Phase T.

(3) $RC = \sum_{t=2}^{T} \sum_{m=1}^{NMF_t} RC_m^{t(t-1)}$: The cost of moving mobile equipment at different intervals, where $RC_m^{t(t-1)}$ costs changes and re-performs from the location t to its previous location t-1. Also $NMF_t$ is the number of mobile facilities in step T.

(4) $DC = \sum_{t=2}^{T} \sum_{j=1}^{F_t} C_o(D_{j_0}^{t-1} + D_{0j}^{t})$: Indicates the equipment distance from the receiver/transmitter which represents the cost of variable equipment from the launcher/receiver with $C_o$ and DS the equipment distance from the receiver/launcher and the equipment after itself.

The limitations of the research are as follows:

(1) Overlap limits-positions that have the ability to overlap with the space of the receiver/launcher station. For example: Control and guard room.

(2) Boundary restrictions-at stations due to the exhaust fence, there should be no area of work or even temporary buildings outside this area. In addition to security issues, the increase in cost and time due to the movement of the fence, it will bring.

(3) Maximum distance limits-the maximum distance of the equipment from each other, as well as from the main equipment of the receiver and launcher in such a way that it does not lead to any interference during commissioning. Note the increase in the distance, the increase in the cost of piping and welding, it will bring.

(4) Minimum distance limits-the minimum distance of the equipment from each other, as well as from the main equipment of the receiver and launcher in such a way that it does not lead to any interference during commissioning.

## 3. RESULTS AND DISCUSSION

According to the methodology described above, the case study of the launcher station/ pipeline receiver of Khorasan Province was examined. Fig. 2 relates to the substitution of the site according to the limitations of the research.

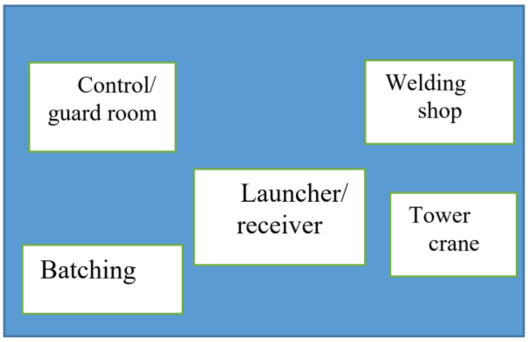


Figure 2. site replacement by applying the limitations mentioned in the methodology.

The equipment and parameters associated with the research are as follows: F1: launcher/receiver; F2: cntrol/guard room; F3:welding shop and piping warehouse; and F4:



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tower crane; F5: batching;

There are different scenarios regarding equipment and displacement distances and changes in research . The scenario is considered to be of importance to F1 as the center and the lowest distance between F2 and F3 from it. The following are tables of intervals and corresponding costs. Using this case, the lowest cost studies are examined with defined constraints and objective function.

Given the complexity of the design and data, using the hyper-innovative algorithms that are invasive in this research, weed is invasive . Using metlab software and data input after 120 iterations the research results are shown in Tables 2 to 6.

Table 2. Minimum distance between equipment (m)

| | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| F1 | 0 | 80 | 60 | 40 | 70 |
| F2 | 80 | 0 | 100 | 120 | 90 |
| F3 | 60 | 100 | 0 | 20 | 110 |
| F4 | 40 | 120 | 20 | 0 | 70 |
| F5 | 70 | 90 | 110 | 70 | 0 |

Table 3. Maximum distance between equipment (m)

| | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| F1 | 0 | 230 | 187 | 85 | 96 |
| F2 | 230 | 0 | 219 | 342 | 178 |
| F3 | 187 | 219 | 0 | 57 | 314 |
| F4 | 85 | 342 | 57 | 0 | 128 |
| F5 | 96 | 178 | 314 | 128 | 0 |

Table 4. The cost of moving between equipment, taking into account the shortest distance (thousand euros)

| | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| F1 | 0 | 300 | 230 | 200 | 250 |
| F2 | 300 | 0 | 520 | 560 | 90 |
| F3 | 230 | 100 | 0 | 20 | 110 |
| F4 | 200 | 120 | 20 | 0 | 70 |
| F5 | 250 | 90 | 110 | 70 | 0 |

Table 5. The cost of moving between equipment taking into account the largest distance (thousand euros)

| | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| F1 | 0 | 750 | 600 | 320 | 480 |
| F2 | 750 | 0 | 700 | 880 | 580 |
| F3 | 600 | 700 | 0 | 210 | 830 |
| F4 | 320 | 880 | 210 | 0 | 128 |
| F5 | 480 | 580 | 830 | 540 | 0 |



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Table 6. Cost of work changes (resulting from changing the position of the equipment)( million euros)

| | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| F1 | 0 | 18.65 | 16.45 | 12.36 | 14.87 |
| F2 | 18.65 | 0 | 18.32 | 25.89 | 17.16 |
| F3 | 16.45 | 18.32 | 0 | 12.45 | 23.54 |
| F4 | 12.36 | 25.89 | 12.45 | 0 | 128 |
| F5 | 14.87 | 17.16 | 23.54 | 16.05 | 0 |

Best cost was obtained from Best Solution equal to 105.87 million euros compared to the defined scenario.

## 4. CONCLUSION

The replacement and equipment of construction and industrial CSLP is of great importance due to the cost and time spent in them. Engineers, managers and employers are always looking to reduce the cost and time they have in direct communication in project management. Oil and gas industry projects are the focus of attention more than other projects due to their economic importance in the country, cost savings and time. In this study, the objective function as a single objective and linear mathematical equation were examined according to the scenario of the importance of launcher/ receiver equipping. Due to the complexity of the calculations, the input data in the software was applied and its output was the optimal answer.

The results of the research by designers, affiliated and active organizations in this field of work, related government bodies, companies and private sectors related to construction projects can be used to optimize the replacement of CSLP equipment. For further validation, the proposed model can also be examined in other ways. It should be noted that this study was evaluated as a single target and that safety, time and other factors can also be applied to the target function and the related results can be compared with this study. On the other hand, each researcher can do data related to their field of work based on this research and compare the results .Research results can also be implemented for accuracy in precision solving software, comparing algorithm and precision solving results and adding to the accuracy of research.



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