



## Ranking the Rework Causes in Iran's Construction Projects and Investigating the Effect of Lean Construction Techniques

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**ABSTRACT:** Rework is one of the common problems in the construction industry. Despite the many studies that have taken place in the world, the lack of a comprehensive examination of the rework causes in Iran is evident. In addition, there is a need to provide an efficient and effective way to improve the rework issues. Therefore, in this study, using the survey method through the questionnaire, the main factors of rework in Iran were identified and ranked according to the criteria of cost, time, quality, safety, and satisfaction of the project team by the Fuzzy-TOPSIS method. Then, lean construction techniques were considered as a strategy to prevent rework, and the impact of these techniques on the importance of the rework factors was tested. The results of 52 questionnaires showed that the factors related to the client, the construction phase, and the design phase were the three main factors of the rework in Iran. Factors for insufficient turnover and commissioning resourcing, late client changes, delaying financing and contract delivery, insufficient skill levels, and ineffective management of project team are also the most important sub-factors, respectively. On the other hand, the lean construction measuring of the projects was examined through the Lean Project Rating System (LPRS) with 14 factors. The results showed that some of the lean construction factors considered in this study (including a focus on communication and collaboration status, the use of IT and RFI) significantly alter rework and the importance of its causes.

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## 1. INTRODUCTION

Building construction often occupies the bottom of industrial productivity rank reports worldwide [1]. On the other hand, rework is one of the major concerns in the construction industry, which creates fundamental problems for construction projects; increasing costs, increasing the duration of projects, dissatisfaction of stakeholders, reducing project quality, and reducing safety are the major consequences of rework [2-4]. According to Love [2], rework has various definitions and interpretations within the construction management literature: terms for it include "quality deviations" [5], "nonconformance" [6], "defects" [7], and "quality failures" [8]. Love [2] characterizes rework as "the unnecessary effort of redoing a process or activity that was incorrectly implemented the first time". Based on a review of other past researches, the definition used in this study for "Rework" is:

"The unnecessary effort of redoing a process or activity that does not meet the requirements or, because of lack of coordination with other activities, will lead to the elimination of some of the performed activities."

In addition, Love et al. [9] in 2010 studied rework in Australian infrastructure projects, they identified about 40

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causes of rework. According to the results of this research, the following five factors were identified as the most important reasons: 1) ineffective use of information technologies; 2) lack of effective client involvement in the project; 3) lack of clearly defined working procedures; 4) changes made at the request of the client, and 5) insufficient changes initiated by the contractor to improve quality.

On the other hand, in general, the purpose of a lean approach is to create the highest value for the customer and reduce or eliminate the waste. Ohno [10] identified 7 waste items including (1) rework, (2) overproduction, (3) inventory, (4) over-processing, (5) motion, (6) transportation, and (7) waiting, and the loss of employee's potential was later added to list by Womack & Jones [11]. In addition, various studies have been done on the impact of lean techniques on project performance. A study conducted in the USA by Salem et al. [12] Shows that the project that implemented lean construction techniques has been completed under the budget and 3 weeks ahead of schedule. In addition, the Satisfaction of the subcontractors has also increased significantly due to communications with the general contractor. Nahmens et al. [13] also showed that after applying lean techniques, job satisfaction in the US industrialized homebuilding sector was elevated by 11%. Thus, various research on lean construction



**Table 1. The average rank of main causes.**

Rank	Main Causes
1	Owner & Client
2	Construction
3	Engineering & Reviews
4	Leadership & Communications
5	Planning & Scheduling
6	Human Resource Capability
7	Material & Equipment Supply

in different countries shows that the successful application of lean principles in construction can improve cost structure [12], delivery times [14], quality [15], the relationship between working partners [12, 16, 17], and job satisfaction [13].

Overall, the first achievement of this article is to integrate the rework causes studied in the world, which has not been fully and completely reviewed in other articles. The second achievement is the localization of the rework causes for Iran. It should be noted that despite extensive studies on the reasons for duplication of construction projects around the world each year, there is no comprehensive study on this issue in Iran. Therefore, one of the main achievements of this paper is identifying the important factors that create rework in Iran's construction projects based on the five criteria of cost, time, quality, safety, and satisfaction of the project team. The third achievement is related to the study of the relationship between lean factors and the importance of the rework causes in projects.

## 2. METHODOLOGY

In this paper, the survey was conducted through a questionnaire and a multi-case study. In this way, respondents were asked to answer a questionnaire according to one of the completed construction projects that they have participated in, and answer the questions based on the experiences of that project. As a result, each completed questionnaire contains information about one case. Also, rework causes are ranked by the Fuzzy-TOPSIS method.

On the other hand, given that Lean construction is new in Iran, and there is little information available on lean constructed projects, instead of asking whether or not the project was made by lean methods, some of the main factors of lean construction are questioned. Finally, a number is assigned as a lean point to each project, indicating the closeness of the project management methods and the organizational management methods associated with the project of choice to lean construction methods. These factors have been extracted from the Hassan [18] study and under the title of the Lean Project Rating System.

First, a pilot survey was undertaken with 10 selected experts. This was undertaken to test the potential response rate, suitability, and comprehensibility of the questionnaire. In the main survey, 65 questionnaires were mailed. 44 valid

responses were received from the main survey. As the pilot questionnaires required no changes, they were added to the sample, which resulted in 52 valid responses representing a total consolidated response rate of 69.3%. This response rate is considered acceptable for a survey focusing on gaining responses from industry practitioners [19].

## 3. RESULTS AND DISCUSSION

In this study, the factors of duplication in Iranian construction projects have been identified and ranked. So, the main causes of rework in their order of priority are presented in Table 1.

In general, the results of the research show that there is no significant relationship between the overall score of the rework factors and the overall lean project score (which includes the 14 items). However, some of these items, including the status of communication and collaboration, and the use of IT and RFI, have a significant correlation with the importance of rework factors, and one can expect that with the help of these techniques, it will be possible to manage the rework and its negative effects.

## CONCLUSIONS

The results of data analysis of 52 construction projects in Iran show that based on 5 criteria of cost, time, quality, safety, and satisfaction of the project team, factors related to 1) owner, 2) construction, and 3) design phase are three important reasons for the main factors of rework. Also, 1) insufficient turnover and commissioning resourcing, 2) late client changes, 3) delaying financing and contract delivery, 4) insufficient skill levels, and 5) ineffective management of project team are the most important sub-factors. Also, the results of correlation analysis of lean construction factors and the importance of rework factors showed that some factors such as communication and collaboration status, the use of IT and RFI can affect the importance of the main factors including engineering, planning and scheduling, leadership and communication, and material and equipment supply. In general, in this paper, despite the limitations of obtaining information on lean construction techniques (the lack of practical application of lean techniques in Iran's construction projects), some of these principles and techniques that are tangible and in the current projects of Iran have given them

attention (Such as the use of IT and RFI, communication status, teamwork, and team experiences) have a significant relationship with the rework causes. Therefore, this research has some limitations in achieving goals. The results are based on Iran's construction projects and may be different in other countries, especially in countries that are leading the Lean construction area. Because this technique is emerging in Iran recently and cannot be considered comprehensively. Also, people working in the Iranian construction industry do not have a complete familiarity with the lean construction philosophy, so performance measurement of lean construction becomes hard. Nevertheless, this paper provides a large study of the factors of rework that would recognize the root cause of rework in the Iranian construction industry, and this, along with the presentation of lean construction techniques, can be fruitful for both researchers and professionals.

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