



Incorporating rework into construction schedule analysis

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ABSTRACT

Rework has been a primary cause of cost and schedule overruns in large construction projects. While several research efforts have analyzed the causes and effects of rework and provided guidelines to reduce rework, almost no research exists to analyze the impact of rework timing and quantity on schedule delays and to support decisions on cost effective recovery. This research presents a quantitative mechanism for schedule analysis considering rework. The mechanism has three aspects: (1) a new schedule representation of rework magnitude as negative percentage complete for affected activities, documented on the specific date on which the rework is detected; (2) a modified daily-windows delay analysis to apportion project delays among the responsible parties; and (3) an optimization technique for determining the least costly corrective action strategy that recovers project delays. The proposed approach is applied to a case study to demonstrate its ability to consider rework impact, in combination with other progress events by other project parties. This research offers an innovative quantitative approach to consider rework timing and amount in delay analysis and corrective action optimization.

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1. Introduction

Rework is a serious problem facing large and complex construction projects, particularly industrial projects that involve multiple parties such as contractors, suppliers, and trades. In such a complex environment where many activities by many parties take place simultaneously, often errors, omissions, and misunderstandings cause undesirable outcomes that have to be reworked. Rework, thus, has been defined as the effort of re-doing a process or activity that was incorrectly implemented the first time [22]. In literature, the term “rework” has been related to other terms such as “quality deviations” [5], “non-conformance” [1,3], “defects” [17], and “quality failures” [4]. Since rework can occur at different stages in the project life cycle, the term “field rework” has been clarified not to incorporate change orders or off-site fabrication errors [8].

Various researchers have studied rework from different perspectives such as rework cycle, root causes, and impact on project performance [19]. [7] introduced the concept of the rework cycle in projects, where the rework itself is not done properly, thus requiring further rework in a recursive cycle that can extend project duration far beyond what is originally conceived. This concept becomes important to the understanding of the interactions

among various project factors including rework, which can be studied using system dynamics tools [24]. With respect to root causes, several studies and surveys were conducted to identify and classify the root causes of rework such as [21]; [25]; [6]; [28]; [5]; [23]; [8]; [20]; [26] and [16]. Almost all studies reported that rework plays a major role in cost and schedule overruns. They identified the main root causes of rework as: errors, omissions, failures, damages, poor leadership, poor communication, and ineffective decision-making. The survey of [21], for example, reported the direct and indirect costs of rework observed in various contract types and identified rework causes related to the design team, client, site management, and subcontractors. Among the various project types, industrial projects have been reported by [16] to exercise the most cost increase due to rework.

With respect to the impact of rework on project performance, various researchers reported observations from case studies, surveys, and interviews among professionals. A summary of the rework cost reported in various studies is shown in Fig. 1. With most studies analyzing rework-related cost performance, [16] recommended conducting further studies on rework impact on schedule performance. The direct costs of rework, however, have been reported to be in excess of 15% of the contract value [4,19]. Using a survey of 115 civil infrastructure projects, it was revealed that the following five significant predictors accounted for 25% of the variance in total rework cost: (1) ineffective use of information technologies; (2) excessive 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

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