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CONSTRUCTION MATERIALS-BASED METHODOLOGY FOR TIME-COST-QUALITY TRADE-OFF PROBLEMS

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Abstract

Time, cost, and quality (TCQ) as a triple constraint of construction projects have dependent and conflicting objectives. Considering the limited resources, estimation of the approximate TCQ is a complex and dynamic problem. In addition, the uncertain nature of construction projects and highly variable alternatives make the decision making process a complicated issue. In order to overcome these difficulties, many researchers in the related academic literature introduced different mathematical models on the TCQ trade-off problem so far. In these models, two different approaches were used to estimate TCQ-related data. In the continues approach, it was assumed that the relationship among these three components could be expressed by continuous functions. In the discrete approach, it was accepted that (i) the construction method, (ii) the crew formation, and (iii) the crew overtime policy have some impacts on the project TCQ and that the relationships among these three components become discrete. However, in previous studies, construction materials that have a significant impact on TCQ of construction activities and projects were not taken into account completely during the data formation process. As an exception, El Rayes and Kandil [1] considered different strengths of concrete as material alternatives in a highway construction project. In fact, all the studies focused on proving the applicability of different optimization techniques instead of optimizing TCQ of a real construction project. In this context, some simple projects including a limited number of activities were used to evaluate the applicability of the developed models. Therefore, in the present study, it is aimed to outline a new two-step methodology, including the alternative construction material utilization, for TCQ trade-off problems, especially for building projects which enable the utilization of the high variety of construction materials. For this purpose, the impact of construction materials on TCQ of a project was explained in a detailed manner.

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1. Introduction

The primary objective of project management is to finish a project within a desired time, cost, and quality. Due to the technological development in today's construction industry, different construction methods, materials, and equipment, which serves to same purposes, can be utilized. During the planning process, by considering these different construction methods, materials and equipment, alternatives are generated, evaluated, and the most suitable one is selected [2, 3]. Thus, the planning process turns to a decision-making process and optimization, which is simply defined as the selection of the best alternative for a given purpose [4], is located in the center of it. Although decisions made in the planning process have a considerable impact on TCQ of a project, they are made with limited information [5]. Therefore, for an effective optimization, all alternatives should be detailed as much as possible. In addition, the uncertain nature of construction projects and highly variable alternatives make the decision making process a complicated issue. In order to overcome these difficulties, many researchers in the related academic literature have introduced different mathematical models on the TCQ trade-off problem by using different optimization techniques so far. However, in previous studies, construction materials that have a significant impact on TCQ of construction activities and projects were not taken into account completely during the data formation process. As an exception, El Rayes and Kandil [1] considered different strengths of concrete as material alternatives in a highway construction project. Therefore, in the present study, it is aimed to outline a new two-step methodology, including the alternative construction material utilization, for TCQ trade-off problems, especially for building projects which enable the utilization of the high variety of construction materials.

2. Theorical Background

Components of TCQ as a triple constraint of construction projects are always in interaction with each other. Any changes made in one of these constraints will likely affect the others negatively or positively. Therefore, generating a construction schedule that allows finishing a project within its scope become an important issue in theory and practice. However, the uncertainties caused by the dynamic environment of construction projects and the highly variable alternatives that can be utilized makes the decision making process complicated. In the literature, to facilitate this process, many researchers developed new models by using different optimization tools to analyze the trade-off among TCQ. In this context, by means of Critical Path Method (CPM), researchers generated alternative construction schedules by considering alternative resource utilizations of each construction activity. Since TCQ constraints of each schedule were compromised by means of optimization tools, it is accepted that none of alternatives predominates the other ones.

Numerous researches were conducted on the time-cost optimization of projects since the development of CPM in the late 1950's. The quality concept was first included to the optimization process by Babu and Suresh [6]. In their study, they argued that the quality of a construction project may be affected by crashing the time and accordingly suggested that the quality concept should also be considered during the optimization process.

In construction projects, time and cost are one dimensional concepts. In other words, time and cost can be expressed by a simple value that creates a common perception among project participants. On the other hand, quality has many dimensions and each dimension creates different perceptions among different practitioners. For example, Foster [7] introduced five different views for quality as follows,

1. ***Transcendent view:*** Quality can be perceived intuitively but cannot be expressed easily, such as beauty or love.
2. ***Product-based view:*** The features and attributes of a product define the quality.
3. ***User-based view:*** If the product satisfies users' needs, then it has a good quality.
4. ***Manufacturing-based view:*** If the product matches the design specifications, then it has a high quality.
5. ***Value-based view:*** If the product offers good value for its price, then it has a high quality.

In this regard, all the dimensions of quality should be perceived equally to create a common perception of quality