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Selection of Construction Equipment by Using Multi-criteria Decision Making Methods

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Abstract

Selecting proper construction equipment is a challenging task in the construction industry due to the broad array of available equipment in the market and a large number of criteria required to be taken into account during decision making. In order to overcome the challenge, multi criteria decision making methods have been proposed to select the proper equipment by ranking the alternatives. This study aims at selecting the proper excavation machine for a construction site by considering qualitative and quantitative criteria including technical specifications, purchasing cost, fuel consumption, service conditions, secondary and replacement parts markets, comfort of the operator. Analytical Hierarchy Process (AHP) and The Preference Ranking Organization Method for Enrichment of Evaluation (PROMETHEE) decision making methods are used to select the proper excavation machine and the results are compared to assess the effectiveness of the methods.

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Keywords: Multi-criteria decision making; equipment selection; excavation machine; AHP; PROMETHEE.

1. Introduction

Minimizing cost of a project is one of the most desired goals for a construction company which in nature is profit-oriented to maintain their existence and position in such a competitive sector. However, making only cost-focused selections can result in making incorrect decisions and neglecting many factors that can be as important as cost. Selection of proper construction equipment is essential for cost, quality and duration of a construction project. The

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rapid development in the manufactory and construction sectors has increased the number of potential construction equipment, which serves the same purpose with different features. In order to select the proper construction equipment for a project, any construction company should take into consideration of many criteria such as ownership cost, operational cost, technical specifications etc. For that reason, the selection of construction equipment can be defined as a multi-criteria decision making (MCDM) problem. There are many MCDM methods such as analytical hierarchy process (AHP), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), Technique to Order Preference by Similarity to Ideal Solution (TOPSIS) for solving the selection problems.

Many researchers have applied various approaches for solving the different equipment selection problems. Skibniewski and Chao [1] applied the AHP method to the crane selection problem. Lin and Yang [2] conducted industrial machinery selection by using the AHP method. Park [3] proposed a knowledge-based expert system called intelligent consultant system for material handling equipment selection and evaluation (ICMESE) for the selection of material handling equipment in a manufacturing facility. Chan *et al.* [4] developed an intelligent material handling equipment selection system called Material Handling Equipment Selection Advisor (MHESA) which contains a database, a knowledge-based expert system and the AHP model to select the equipment type. Bascetin [5] selected a loading-hauling system by using an AHP-based model for coal production in an open pit coal mine. Chakraborty and Banik [6] proposed an AHP model for selecting a material handling equipment. Goldenberg and Shapira [7] developed an AHP-based model for selecting cranes, concrete pumps and formwork systems. Dağdeviren [8] developed a decision support system to select milling machine for an international construction company. The system integrated AHP and PROMETHEE methods.

Onut *et al.* [9] proposed a combined MCDM methodology which integrated fuzzy analytical network process (ANP) and TOPSIS to select a material handling equipment for a steel construction company. Ulubeyli and Kazaz [10] applied ELECTRE III method to the concrete pump selection problem. In order to solve the material handling equipment selection problem, Tuzkaya *et al.* [11] developed an integrated fuzzy MCDM methodology, which evaluates the criteria by fuzzy ANP and compares the alternatives with fuzzy PROMETHEE. Bazzazi *et al.* [12] proposed a fuzzy MCDM method to select the suitable loading haulage equipment for the open pit mines. Anand *et al.* [13] conducted the AHP method for selecting the material handling systems. Yılmaz and Dağdeviren [14] developed an integrated system which combines fuzzy PROMETHEE and zero-one goal programming to the equipment selection problem. Paramasivam *et al.* [15] applied digraph and matrix approach as well as the AHP and ANP methods to milling machine selection problem. Lashgari *et al.* [16] proposed an integrated model based on the ANP, fuzzy AHP, and TOPSIS methods to select the loading and hauling system. Yazdani-Chamzani and Yakhchali [17] applied fuzzy AHP and fuzzy TOPSIS methods to tunnel boring machine selection for a construction project. Phogat and Singh [18] applied 5 different MCDM methods to select proper construction equipment for a road construction project. The applied methods were AHP, simple additive weights method (SAW), ELECTRE, PROMETHEE and TOPSIS. Swant and Mohite [19] developed a decision support system by applying TOPSIS, block TOPSIS and modified synthetic evaluation methods (M-TOPSIS) for automated guided vehicles. Anbarcı *et al.* [20] proposed the VIKOR method to select suitable backhoe loader.

Literature review proves that MCDM methods have been successfully applied to the equipment selection problems. However, selecting the most suitable method for solving the problem still remains unclear. This paper aims at comparing the AHP and PROMETHEE methods to select the optimum excavation machine for a construction company in Izmir, Turkey. Criteria weights were defined by using the AHP method and the alternatives were evaluated by the AHP and PROMETHEE methods which have different approaches for outranking the alternatives.

2. Methodology

2.1. AHP Method

The AHP method was developed by Saaty in 1980 [21]. This method allows decision makers to consider both quantitative and qualitative criteria based on pairwise comparisons and shows the relations between the objectives, evaluation criteria, sub criteria and alternatives in a hierarchical way. After structuring the hierarchy, the relative importance of decision criteria are assessed by comparing the decision alternatives with respect to each criterion,