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Prediction of site overhead costs with the use of artificial neural network based model

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ABSTRACT

Overheads, especially site overhead costs, constitute a significant component of a contractor's budget in a construction project. The estimation of site overhead costs based on traditional approach is either accurate but time consuming (in case of the use of detailed analytical methods) or fast but inaccurate (in case of the use of index methods). The aim of the research presented in this paper was to develop an alternative model which allows fast and reliable estimation of site overhead costs. The paper presents the results of the authors' work on development of a regression model, based on artificial neural networks, that enables prediction of the site overhead cost index, which used in conjunction with other cost data, allows to estimate site overhead costs. To develop the model, a database including 143 cases of completed construction projects was used. The modelling involved a number of artificial neural networks of the multilayer perceptrons type, each with varying structures, activation functions and training algorithms. The neural network selected to be the core of developed model allows the prediction of the costs' index and aids in the estimation of the site overhead costs in the early stages of a construction project with satisfactory precision.

1. Introduction

The issue of a sufficiently reliable overheads estimation is vital for the potential contractor. According to the research presented in one of the previous works by Plebankiewicz and Leśniak [33] the influence of improper calculation of the overhead costs can be significant for the financial situation of the contracting company.

Generally, the building contractor's overhead costs are divided into two categories: site (project) overhead costs and company's (general) overhead costs [32]. Site (project) overhead costs include items that can be identified with a particular job, but not materials, labour, or production equipment. Company's overhead costs are items that represent the cost of doing business and often are considered as fixed expenses that must be paid by the contractor. In literature one can find different definitions of overhead costs [1,5,26,33,36]. On the other hand, an overhead cost of a construction project can be defined as a cost that cannot be identified with or charged to a construction project or to a unit of construction production [21]. Cilensek [19] describes

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overhead costs as those that are not a component of the actual construction work but are incurred by the contractor to support the work. The overheads include expenses that cannot be charged directly to a particular branch of work but are required to construct the project [23]. According to Polish standards of cost estimating [38], site overhead costs can be defined as all the costs incurred by the contractor on the building site in connection with the works realization, excluding the direct costs.

Overhead costs are widely discussed in literature. Relevant research on overhead costs can be divided into four main research trends [36]. Some of the researchers focus on the analysis of situation and statistical research on the understanding of the overhead costs concept, analysis of construction delays vs. overhead costs, analysis of the construction company's overhead costs distribution, and allocation and analysis of fixed expenses recovering. Assaf et al. [6] investigated the overhead costs practices and showed how the unstable construction market makes it difficult for construction companies to decide on the optimum level of overhead costs. The practices of estimating overhead costs are investigated in various countries (e.g. Great Britain [14], the USA and Canada [30], Lithuania [36], Saudi Arabia [6], Poland [33]). Particular attention is paid to a detailed computation of site overheads. A number of empirical studies relate to the determination of the project overhead cost. Factors that influence project overhead cost are widely discussed in literature in various aspects [5,17,40]. Some of them emphasize that project time is an important factor affecting project overheads [11,27]. Cooke [20] highlighted that the location of the site could affect a number of project overhead items. Brook [11] indicated that the method of work was a critical factor affecting the amount spent on project overheads. A detailed overhead costs categorization and the selection of the principal parameters of the company's activity, on which the value of overhead costs depends, was presented by Šiškina et al. [36]. Apanavičienė and Daugėlienė [2] proposed a new classification of construction companies into competitiveness classes according to the relative value of overhead costs. In other work [34], it was commented that a contractor's overhead costs, though varying from trade to trade, were dependent on annual volume of work, job type, job size, local economic conditions, support staff and equipment requirements. El Sawy et al. [25] after having conducted a series of surveys, proposed a list of factors that contribute to site overhead cost in the Egyptian construction market. The researchers in their investigations on overhead costs or its elements use different tools for instance: case-based reasoning [17], neural networks [25], exploratory factor analysis [12]. Some of the authors analyze the issue taking into account principal parameters of the construction company's activity, on which the value of overhead costs depends [36]. In other work a new classification of construction companies into competitiveness classes according to the relative value of overhead costs was proposed [2].

Artificial neural networks (ANN) refer to mathematical structures and their software-or hardware-based models which compute or process signals. The structure of the network and its mode of action is based on the brain and learning phenomena; however neural networks constitute a strongly simplified model [39]. The theory of neural networks is widely presented in literature (e.g. [9,28,31,39]). The main application of artificial neural networks includes the following [28,31]: prediction, approximation, control, association, classification and pattern recognition, associating data, data analysis, signal filtering and optimization.

Artificial neural networks began to be used in the management of construction projects in the early nineties of the last century [37]. Until today there have been a number of attempts to use artificial neural networks in engineering construction processes regarding such issues as implementation time analysis, efficiency and productivity in construction projects [24,35], predicting the maintenance cost of construction equipment [45], predicting the adoption potential or acceptability of a new construction technology [37], construction company management [13,16,18] and facilitating decision making processes in construction projects [4,42].

Apart from the issues mentioned above, there have been other attempts to apply artificial neural networks to the management of the costs involved in construction projects. One of the first publications on this topic, by Hegazy and Amr [29], aimed at the creation of a ANN-based cost-estimating model which would allow to estimate the costs of constructing motorways. A similar problem was described in [43,44]. In [41] authors described a new multi-stage framework based on ANN for cost-optimal analysis to support the deep renovation of buildings. The cost formulas for estimate sheet metal parts composed by applying neural networks was proposed in [3]. The application of ANN, in the field of construction cost management concerned also predicting cash flows [10], predicting cost deviations in high-risk projects including reconstruction, alteration, rebuilding projects [7], evaluating of project budget implementation [22] estimation of overheads in dam projects [25] or analysis of construction claims outcomes [15].

The aim of this paper is to present the results of the research on the development a regression model based on artificial neural networks which supports the prediction of the site overhead cost index and thus allows quick estimation of site overheads costs within an acceptable error range. The solution to the problem involves finding such a form of the model that will enable a specification of the site overhead cost index for construction projects. The authors' basic assumption was the application of artificial neural networks in the model, since their key feature and main advantage is their ability to generalize knowledge. This generalization allows the generation of appropriate solutions for data that did not appear in the training data set.

2. Concept of model and research phases

The authors' assumption was the development of a model that would allow the specification a site overhead cost index for a construction project. Such an index, on the basis of a computational formula, could enable a quick assessment of site overhead cost for a certain construction project. In their research, the authors intention was to develop a regression model implementing an artificial neural network. The term ''regression'' refers to a modelling function mapping a set of values of describing variables on the set of values of the