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Working Out The Quantities of Civil Engineering Structures

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Abstract - *Cost estimation is the most important preliminary process in any construction project. Therefore, construction cost estimation has the lion's share of the research effort in construction management. In this paper, we have analysed and studied proposals for construction cost estimation for the last 10 years. To implement this survey, we have proposed and applied a methodology that consists of two parts. The first part concerns data collection, for which we have chosen special journals as sources for the surveyed proposals.*

The second part concerns the analysis of the proposals. To analyse each proposal, the following four questions have been set. Which intelligent technique is used? How have data been collected? How are the results validated? And which construction cost estimation factors have been used? From the results of this survey, two main contributions have been produced. The first contribution is the defining of the research gap in this area, which has not been fully covered by previous proposals of construction cost estimation. The second contribution of this survey is the proposal and highlighting of future directions for forthcoming proposals, aimed ultimately at finding the optimal construction cost estimation. Moreover, we consider the second part of our methodology as one of our contributions in this paper. This methodology has been proposed as a standard benchmark for construction cost estimation proposals.

Keywords- *Vibrofloat, Reclamation, Stabilization, Soil*

1. INTRODUCTION

Information technology (IT) plays a crucial role in dealing with challenges in construction projects. Thomas etal. have illustrated the importance of using IT to improve the performance of construction projects. The construc-tion industry faces numerous complicated challenges that go beyond IT. These complicated challenges motivate the use of intelligent techniques to handle those challenges. For instance, intelligent techniques may be used to handle challenges such as selecting the best-qualified prime contractor, predicting project performance at different phases, or estimating risk for cost overruns (running beyond a proper plan may lead to greater risks for many contractors). Recently, the civil engineering community has begun to consider Artificial Intelligence (AI) techniques as an optimal art for handling the above 3 fuzzy and ambiguous challenges . The use of AI in the civil engineering sector has been introduced by Parmee , who proposes for AI to tackle problem areas characterised by uncertainty and poor definition.

2. RESEARCH METHODOLOGY

The importance of cost estimation in the construction indus-try has been discussed in the previous section. However, there is no doubt that intelligent solutions may solve the dilemma of cost overruns, considering all affecting factors. In fact, there are a huge number of intelligent techniques available to deal with problems in construction management . This motivates the researchers to carry out and analyse intelligent techniques with regard to tackling the construction cost esti-mation problem. This paper surveys the intelligent solutions employed over the last decade and identifies the directions for future ----development. This will help to provide more precise and in-depth analysis for the most recent proposals. The analytical process will highlight the research gap in this area. Furthermore, it will open a door for defining the available opportunities for future research.

This research has been divided into three parts, as shown in Figure 1. Firstly, we create a literature review database on the intelligent techniques that have been used in cost estimations over the last decade. In this step, specific journals have been selected based on their specialisation both in construction management and in information technology. These journals are Journal of Computing in Civil Engineering (http://ascelibrary.org/journal/jccee5), Journal of Construction Engineering and Management Advances in Civil Engineering. Con-sequently, the collected papers have been classified based on their applied techniques. Secondly, we present an analysis and discussion of each intelligent technique to clarify its strengths and weaknesses. The strengths and weaknesses of specific intelligent techniques will be inherited by the cost estimation method based on that technique. Additionally, cost affecting factors have been established in order to carry out a specific benchmarking process.

Later, an intensive comparison of the surveyed construc-tion projects' cost estimation methods, based on a proposed benchmark, has been conducted. To analyse each proposal, the research has focused on four points:

(i) The intelligent technique in use;
(ii) How the proposal's data is collected;
(iii) Validation of the proposed idea;
(iv) The coverage of cost estimation factors.

3. CONSTRUCTION COST FACTORS

According to Shane et al. , Oberlender and Trost , and Ahiaga-Dagbui and Smith, any construction cost estimation should be developed based on specific parameters such as type of project, material costs, likely design and scope changes, ground conditions, duration, size of project, type of client, and tendering method. Therefore, in this paper we have introduced these factors as a benchmark to compare between the cost estimation proposals.

There are various different factors that affect cost estima-tion in construction projects. These factors can be clustered into two distinct groups: (i) estimator-specific factors and (ii) design and project-specific factors.

3.1. Estimator Specific Factors : The cost estimator can be one of the three parties: contractor, consultant, or owner. Based on the estimator's background and experience, cognitive

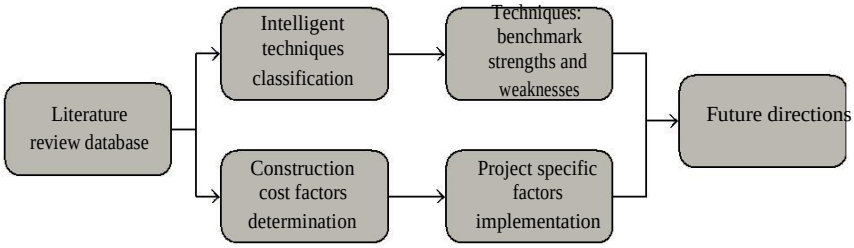

Figure 1: Flow chart illustrating the methodolog

biases or errors in cost estimates may occur accordingly [11]. In many cases, the cost estimator makes decisions based on the likely gains, or losses, of a venture and not necessarily based on the real outcome of the decision [12]. Moreover, the individual estimator may customise pricing based upon best local practices [13], which differ from country to country. For this reason, this paper will focus on design and project-specific factors.

3.2. Design and Project-Specific Factors : These factors include project size, type of project, ground conditions, type of client, material costs, likely design and scope changes, duration, ten-dering method [6, 9, 10], and contract type. In the following paragraphs, these factors are discussed in detail to explore their meanings and functions regarding cost estimation.

3.2.1. Project Size *:*There is a strong correlation between project size in square feet or metre and the number of labours. However, as the number of labours increases, the cost estimation of some items may have some biases and become more plausible (e.g., production rate estimation or tasks scheduling). There are many empirical studies on how project size can influence cost estimation

3.2.2. Type of Project.*:* Undertaking particular types of projects requires a suitable choice of technology and equip-ment used, as well as suitable work methods. However, this can limit the choice of materials and size of crew to be employed; consequently, this will affect the project budget.

Project types can be classified under several different categories. In general, there are six major types of con-struction projects: (1) building construction, (2) special-purpose construction, (3) heavy construction, (4) highway construction, (5) infrastructure construction, and (6) indus-trial construction.

3.2.3. Ground Conditions. Before tendering, ground condi-tion should be one of the first concerns in any construction project. Without knowing the ground condition, the contrac-tor should still presume to estimate the cost; however, if the assumption is not proper, this will lead to additional costs for bad ground condition.

3.2.4.*Type of Client*. As each construction project has its own client ideas, roles, and objectives, the characteristics of the contract and bidding behaviour are mainly affected by client type. There are seven different types of clients as classified by Dreweta

1) Government.
2) Housing Authority.
3) Other public sector clients.
4) Large developers.
5) Large industrial, commercial, and retailing organisa-tions.
6) Medium and small industrial, commercial, and retail-ing organisations.
7) Other private sector clients.

3.2.5. Material Costs. The material selection-time, type of materials, and their availability in the local market all demonstrate a statistically significant impact on the cost estimation of construction projects. Materials can represent up to 70% of the project construction cost hence, any methods used to estimate the material cost accurately will reduce wastage and improve the major project's cost and time benefits. In addition, the quantity of material required must be accurately measured from the drawing and is not dependent on the crew performance or work method adopted However, this factor can vary dramatically and is highly dependent on the performance and work method used by the labours.

3.2.6. Likely Design and Scope Changes. Depending on their level of experience, the client retains more influence over the design and once on site during construction. Certain types of projects require the client to appoint a design firm (Figure 2) to design and inspect the project phases, in order to achieve the standards expected by the client.

On the other hand, the right scope definition phase is highly important in the pre-project planning process. Poor scope definition is recognised by industry practitioners as one of the leading causes of project failure, as a high level of pre-project planning effort can result in around a 20% saving on total costs

4. INTELLIGENT CONSTRUCTION PROJECT COST ESTIMATION METHODS

In this section, analysis of the surveyed intelligent construc-tion cost estimation methods was conducted. These methods have been categorised into five groups, based on the intelli-gent technique that is used in each group: machine-learning (ML), rule-based systems (RBS), evolutionary systems (ES), agent-based system (ABS), and hybrid systems (HS).

At the first step, each group is explored to highlight their strengths and weaknesses. Subsequently, the methods are analysed in depth in terms of coverage of construction cost estimation techniques. In each proposal, four key questions have been highlighted for analysis. These questions are (1) which intelligent technique is used; (2) how the input datasets are collected; (3) how the proposed method is validated; and which construction cost estimation factors are covered. In the following subsections, firstly, the intelligent tech-niques employed are discussed, is the findings of which are considered as an answer to the first question. Secondly, each proposal is analysed individually, which answers question 2. The content of Table 1 illustrates the answer of question 3, while the content of Table 2 illustrates the answer of question 4.

4.1. Machine Learning (ML) Systems. ML systems have been defined as a construction of a system that can learn from data. In general, the main strengths of ML are (i) the ability to deal with uncertainty, (ii) the ability to work with incomplete data, and (iii) the ability to judge new cases based on acquired experiences from similar cases. On the other hand, the main weakness of ML is the lack of technical justification; that is, the causes beyond the decision are not available. This type of decision is called a black box decision. However, in the construction management, the artificial neural network (ANN) and the support vector machine (SVM) are the most

5. CONCLUSION AND FUTURE DIRECTIONS

In this paper, a survey and analysis were performed on dif-ferent proposals in order to tackle the problem of developing construction cost estimation based on intelligent techniques. A scientific methodology has been designed to implement this survey. The method of the presented paper was based on two parts. The first part was concerned with a literature survey to examine the current state of intelligent solutions in the construction industry. Regarding this matter, we have chosen exclusively the journals that specialise in both infor-mation technology and construction management, within a time frame of ten years. In the research context, a ten-year period is sufficient to surround the directions of research in a specific area.

The second part was concerned with analysis of the proposals collected in the first part. Four key questions were selected to analyse each proposal. These questions are as follows.

(i) What is the intelligent technique used?
(ii) How is the proposal's data collected?
(iii) How is the proposed idea validated?
(iv) What are the construction cost estimation factors used?

A justification of the four questions has been provided as follows.

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(1) Defining the Intelligent Technique Used. This question is used to highlight the general strength and limi-tations of each proposal, which are reflected by the technique employed.
(2) Defining Data Collection Method. This question is used to ensure the degree of accuracy. The degree of accuracy mainly depends on the collected data.

(3) Defining the Validation of the Proposed Idea. T his question is used to ensure the applicability of the proposed idea.
(4) Defining the Commonly Used Cost Estimation Factors. This question is used to ensure the completeness of the proposal.

As mentioned in Section 3, there are two types of con-struction estimation factors: estimator-specific factors and design and project-specific factors. The first type, estimator-specific factors, depends on estimator expertise and skills and on lack of standardisation. The second type, design and project-specific features, is well defined and established in the civil engineering community. Due to the standardisation and stability of design and project-specific factors, this research paper considered only those factors mentioned in the designed methodology when applying the benchmark.

In conclusion, this paper provides two contributions to this area of knowledge: (1) an analysis of construction cost estimation proposals and (2) a standard survey methodology that can be used in any future surveys that deal with construction cost estimation.

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