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ORIGINAL ARTICLE

Cost analysis of continuous flight auger piles construction in Egypt

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Abstract Continuous Flight Auger (CFA) piling is widely used in the Egyptian construction industry. There is a dramatic fluctuation in pricing of executing this work package within short periods as a result of unsteady changes in supply-demand equilibrium. Consequently, there is an urgent need for the use of a scientific approach in estimating construction costs. Accordingly, it is crucial to consider the different cost elements of CFA piling construction as a step to reach an accurate and realistic cost estimate to be used by contractors in tendering. This research aims to study these cost elements based on an expert judgment, site observations and statistical analysis in order to develop an effective tool to estimate the total construction cost of the CFA piles in any future project. Expert survey was performed to draw detailed information to construct a cost breakdown structure (CBS) that was used as a basis for developing the proposed cost model. The developed cost model is then validated through the application on fifty two projects. Such projects were carefully selected in different sizes, purposes and locations. Then the collected data were exposed to statistical analysis techniques. An average percentage error of 4.1% was observed upon comparing the estimated costs with the actual costs of these projects. A sensitivity analysis was then performed to recognize the most effective cost factors. The developed recommended model was used by some experienced contractors in the Egyptian market who expressed their satisfaction with the model.

1. Introduction

A basic objective of construction equipment management was to accurately estimate the cost of construction operations to facilitate tendering, financing, funding and cost control of construction projects. The use of Continuous Flight Auger (CFA) piles is expanding in the Egyptian construction industry as it is the most appropriate for the different ground conditions with a variety of diameters and depths [10]. The prices of constructing CFA piles are dramatically changeable even by increase or decrease within short periods as a result of changes in the supply–demand equilibrium especially in the Egyptian market. The potential stability of the Egyptian market within the future years may affect this problem as the current status will not be accepted in a steady market. Meanwhile, there is insufficient research and industry attention to analyze and estimate the costs of CFA piles construction in the Egyptian operating conditions with unique marketplace

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Nomenclature

ABC	activity based costing
AC	actual cost
C	individual cost of an item or work package
CBS	cost breakdown structure
CC	construction cost
CCC	CFA cost calculator
CFA	continuous flight auger
DC	direct cost
d	daily wage rate of a human resource in pounds
EC	estimated cost
k	unit cost of a consumable (fuel, oil or grease)
L	lump sum amount of cost in pounds
n	number of project working days
Q	total quantity of piling in meter run
MS-Excel	microsoft excel software
PMIS	project management information system
R	daily consumption rate of a consumable (fuel, oil or grease)
SLD	straight line depreciation
TC	total cost
UML	unified modeling language
z	number of human resource peers for a specified job
4WTT	four wheel type tractor (Loader)
6WT	six wheeler truck
18WT	eighteen wheeler truck

factors [10]. The proposed research is an approach to study such a problem with an aim to reach a reliable solution.

2. Literature review

An estimate is an approximate prediction that provides information for decisions and is a substitute of actual measurement that is not economical or possible. It is accurate if it is close to the actual performance. The estimating job has been changing because of the increased complexity and size of construction projects [1]. The term estimate is a loose term in construction industry and its precise meaning is determined from the context in which it is used. It may refer to preliminary cost estimates, detailed cost estimates or quantities estimates [2].

There are many studies dedicated to cost estimates of construction equipment in general or especially CFA piling construction: Tumblin [2] defined "preliminary cost estimates" as quick estimates that may be needed to decide the availability of funds or to confirm the feasibility of a project, while "detailed cost estimates" is an accurate approach based on four categories of expenses: material, labor, equipment and subcontractors cost. The cost of materials and subcontractors are based on relatively fixed prices and can be accurately determined while the area of uncertainty lies in the selection of the proper unit cost and production rates of labor and equipment. Abdel-Razek and Mccaffer [3]: Performed several studies to determine residual variability within estimator calculations and developed simple computer models to calculate labor rate, plant rate, cost of materials, subcontractors cost and labor productivity. Peurifoy and Ledbetter [4]: Classified the total price of a construction operation into labor costs including salaries, transportation, insurance, taxes, training, recognition and rewards; material costs including purchasing, transportation, inspection and storage; equipment costs including ownership costs such as purchase, investment and storage of equipment in addition to equipment operating costs of consumables, minor and major maintenances plus construction overheads. Richardson [5]: Provided many approaches and templates to be used as a standard in estimating the construction costs but this was a general standard which needs some adjustment to work on CFA piles construction especially in the Egyptian operating conditions. Olwan [6]: Developed an integrated database and cost control system for construction projects based on labor/crew system, material system, equipment system, subcontractor system and overheads. Zayed [8]: An early approach to determine CFA costs but he claimed his failure to collect data from experts as they considered it confidential and not for public use. Therefore he considered material, equipment, labor and overheads as a basis for his estimate. This research was built on prices in USA and the approximate total cost for a pile ranged from 745 to 900 USD which cannot be applied in the Egyptian market not only due to different working conditions but also due to instability of currency exchange rates. Gabon [9]: Presented a study conducted to plan the construction of continuous flight auger operations using artificial neural network with cost time trade-offs to optimize the efficiency of such piling job. Fraig [11]: presented a simulation of CFA pile construction to assess productivity using time recording and activity sampling techniques to determine the amount of idle time and its effect on project objectives. Department of Defense, USA [12]: Developed a handbook for construction cost estimating that announced three main categories of construction cost: Direct costs that are attributed to a single task of construction work (labor, material, and equipment); Indirect costs that cannot be attributable to a single task of construction work (overheads, markup, bonds, taxes. . .etc.) and other costs (contingency reserves, testing, inspection and special requirements). Maowad [13]: Developed an integrated cost control system for construction costs using Unified Modeling Language (UML) with a case study applied on pump station projects in Egypt using artificial intelligence which could be applied on other construction jobs. A Guide to the Project Management Body of Knowledge [14]: The internationally recognized standard mentioned the sources of cost estimating procedures to be the following: expert judgment, historical data, regional and global markets and project management information system (PMIS). Bearing on the previous literature, it was clear that (1) some studies are missing vital cost elements, (2) most of them are covering cost estimates in general, (3) few approaches concentrated on piling costs with inaccurate results due to banned actual data by industry practitioners and (4) none of them studied the cost of CFA piles under the Egyptian working conditions which will be the main objective of this study.

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