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Qualitative Risk Analysis for Driven Piles Activities

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ABSTRACT

The construction of deep foundations has many challenges owing to increase the unforeseen parameters controlling the process of construction. Driven piles based on the Precast Reinforced Concrete (PRC) technology is considered one of the deepest foundations types that used in water structures in Egypt such as bridges. The construction process for such projects faces many challenges as the presence of several risk factors, which have significant effects on the project objectives (i.e. cost, time, quality and scope) although there are huge investments spent on these types of projects. For that, this work addresses and identifies the expected risks associated with the main activities of driven piles execution, based on PRC technology. The technique of field survey for the purpose of data collection is used in this work. Identification and qualification analyses are conducted to define the priorities of risk factors affecting the planned activities as well as the Risk Breakdown Structure is developed. This will help in producing the risk register for preparing risk management plan of upcoming projects. The list of most important risk factors includes (1) Poor materials quality risk factor that affect Preparing and casting piles activity; (2) Poor system of fixing pilling machine risk factor, which affect the Positioning piles and steering the pilling machine activity; (3) Lack of specialized equipment's, which affect Handling piles activity (4) Differences between soil boring report and in-site soil, which affect Driving piles activity. Based on the obtained results, this work provides valuable data and guidance for the Egyptian government and local partners to have an in-depth understanding of the risk factors affecting the activities associated to the construction of Driven Piles. These findings are essential for implementing further effective measures to ensure the decision makers for future development and create a more attractive market to these types of projects in Egypt.

Key words: Risk, risk analysis, Driven piles

INTRODUCTION

Construction management plays an important role for the sustainability and resilience of infrastructure projects to meet the expected objectives and establish polices to deal with the unexpected risks. The project risk is an uncertain event or condition that, if it occurs, has a positive or a negative effect on at least one project objective [1]. A risk may have one or more causes and, if it occurs, one or more impacts. Risk in construction has been the object of attention because of the cost overrun and time delay associated with construction projects [2]. Cost overrun and time delay are two serious problems that the construction industry faces due to the impact of the risk factors. They are costly for both owner and contractor. The owner may lose by missing out on the potential revenues from the use of the project and by increased overhead cost for contract administration and supervision.

Egypt is considered one of the biggest countries which have a large network of irrigation and drainage systems in order to fulfill the requirements of agricultural activities. The majority of water canals in Egypt is located adjacent to roads, highways and railways and pass inside villages/towns [3]. This causes a barrier for people to transport from side to another in villages/towns. To facilitate the transportation of residents in such areas, huge number of bridges over water canals is proposed. Due to the closeness of buildings and railways to water canals in Egypt, it is

difficult to divert waterways during bridges construction. Subsequently, driven piles is considered the appropriate foundation type used in bridge construction over canals in Egypt to avoid diversion of the pathway of water canals [3]. The selection of material piles depends on the location and type of structure, the ground conditions, and durability [4]. Generally, pile foundations can be classified into three categories when piles are used to reduce settlement based on their design [5]. These categories include large displacement piles, small displacement piles and replacement piles. The first two categories can be driven or jacked into the ground and thus displace the soil. This section presents a brief description for design, construction techniques and activities associated with driven piles. Design of driven piles to support loads is one of challenges faces the geotechnical engineer since owing to several parameters control the design process. There are two ways for transferring loads from piles to soil, shaft friction and base resistance or end-bearing. The transferring of loads from pile to soil depends on type of soil, type of pile material, loads and type of loads. By knowing all these parameters, the carrying capacity of piles can be determined and the pile can be designed to resist the required loads safely [6]. Construction technique used for Driven Precast Reinforced Concrete Piles (DPRCP) includes preparation of concrete piles and installation of piles by driving. More attention should be given during the process of installation for this type of piles to meet both standards and safety.

To sum up, the activities of Driven piles execution in bridge construction faces many risk factors that affect the project success. Consequently, the main objective of this paper is analyzing risk factors affecting the activities associated to the construction process of driven piles. While the specific objective of this research is to identify and explore the various components of risk factors affecting the activities of construction driving piles in bridges throughout the Egyptian context.

RESEARCH METHODOLOGY

Two brainstorming sessions are proposed to be conducted in the Ministry of Water Resources and Irrigation, Egypt, with professionals in the field of executing R. C. Bridges that executed over driven piles. Due to shortage of data, the brainstorming is considered one of the most common data collection techniques in construction engineering projects. The objective of these sessions includes ensuring and updating the main activities and risk factors affecting each activity for these piles that introduced by the researchers. The main contribution is conducting a qualitative risk analysis to the mentioned factors for the purpose of highlighting the most important of them.

Two sessions are conducted in two Egyptian cities with a fairly open framework which allows for conversational and two-way communications. Most of the attendees have suitable experiences since they are responsible for management, planning and execution of most of these projects in their governments. In addition, attendees included clients, consultants and contractors who work in executing such projects.

Qualitative Risk Analysis

The identified risks can be assessed qualitatively to determine their likelihood and potential effect on project objectives, allowing risks to be prioritized for further attention [7]. The primary technique for this is the Probability – Impact Matrix, where the probability and impacts of each risk are assessed against defined scales, and plotted on a two-dimensional grid. Position on the matrix represents the relative significance of the risk, and high/medium/low zones may be defined, allowing risks to be ranked.

Qualitative risk analysis includes different methods for prioritizing the identified risks for further actions (i.e. Quantitative Risk Analysis or Risk Response Planning). Organizations can improve the project's performance effectively by focusing on high-priority risks [1]. Qualitative Risk Analysis assesses the priority of the identified risks using their probability of occurrence, the corresponding impact on project objectives if the risks do occur, as well as other factors such as the time frame and risk tolerance of the project constraints of cost, schedule, scope, and quality.

Risk Factors Affecting Driven Piles

The aim of risk factors identification is to comprehensively identify all significant sources of factors affecting project objectives such as time, cost and quality as well as the causes of those factors. There is one possible way of understanding and structuring the risks that face any project is to combine the holistic approach of general systems theory with the discipline of a work breakdown structure as a framework [8]. The Work Breakdown Structure (WBS) assists in the identification of factors by simplifying the project structure into smaller units, for estimating the project cost more accurately and analysing correlations that may exist between any two cost centres [9].

There are four identified activities associated with the construction and installation of driven piles as presented in previous work [3]. These activities are: (A) preparing and casting the piles; (B) positioning piles and steering the

pilling machine; (C) handling piles; and (D) driving piles. For each activity, there are many risk factors affecting the execution activities and these factors are varying from activity to another based on the type of activity. For better illustrations, the risk factors control each activity are shown in Figure (1) in a form of Risk Breakdown Structure (RBS). More details and analysis will be illustrated in next section.

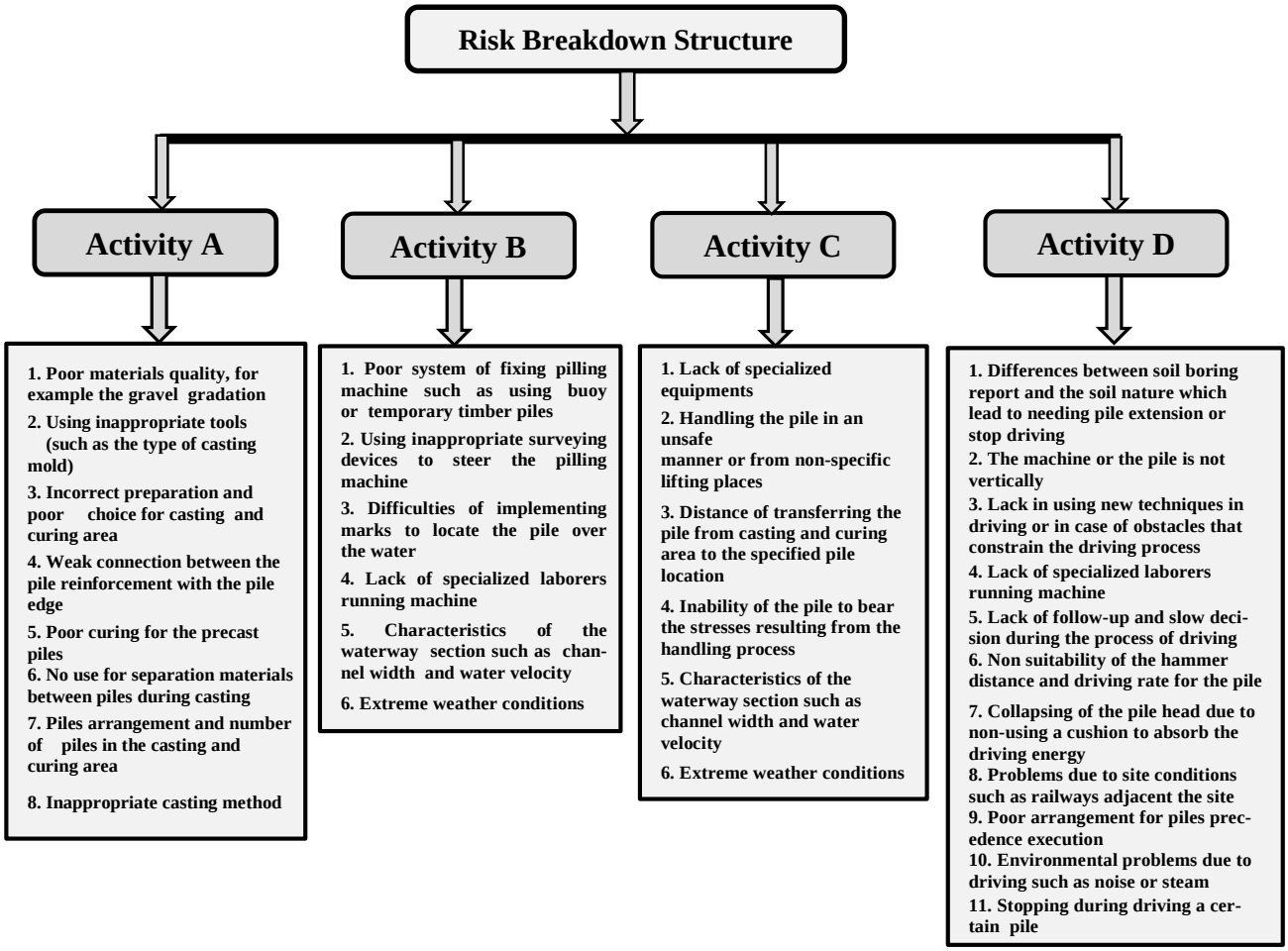

Fig. 1 RBS for for factors affecting the activities of DPRCP

RESULTS OF RISK ANALYSIS

As a result, from the brainstorming sessions, the risk factors priority for each activity is ranked due to their importance. Tables 1 through table 4, summarize these priorities.

Table -1 Descriptions of Risk Factors Control the Executed Activity (a) for Driven Piles in Egypt

A –Risk Factors affecting: Preparing and casting the piles activity	*Rank*
Poor materials quality, for example the gravel gradation	1
Using inappropriate tools (such as the type of casting mold)	2
Incorrect preparation and poor choice for casting and curing area	3
Weak connection between the pile reinforcement with the pile edge	4
Poor curing for the precast piles	5
No use for separation materials between piles during casting	6
Piles arrangement and number of piles in the casting and curing area	7
Inappropriate casting method	8

Table -2 Descriptions of Risk Factors Control the Executed Activity (b) for Driven Piles in Egypt

B- Risk Factors affecting: Positioning piles and steering the pilling machine activity	***Rank***
Poor system of fixing pilling machine such as using buoy or temporary timber piles	1
Using inappropriate surveying devices to steer the pilling machine	2
Difficulties of implementing marks to locate the pile over the water	3
Lack of specialized laborers running machine	4
Characteristics of the waterway section such as channel width and water velocity	5
Extreme weather conditions	6

Table -3 Descriptions of Risk Factors Control the Executed Activity (c) for Driven Piles in Egypt

C- Risk Factors affecting: Handling Piles activity	***Rank***
Lack of specialized equipments	1
Handling the pile in an unsafe manner or from non-specific lifting places	2
Distance of transferring the pile from casting and curing area to the specified pile location	3
Inability of the pile to bear the stresses resulting from the handling process	4
Characteristics of the waterway section such as channel width and water velocity	5
Extreme weather conditions	6

Table -4 Descriptions of Risk Factors Control the Executed Activity (D) for Driven Piles in Egypt

D-Risk Factors affecting: Driving piles activity	***Rank***
Differences between soil boring report and the soil nature which lead to needing pile extension or stop driving	1
The machine or the pile is not vertically	2
Lack in using new techniques in driving or in case of obstacles that constrain the driving process	3
Lack of specialized laborers running machine	4
Lack of follow-up and slow decision during the process of driving	5
Non suitability of the hammer distance and driving rate for the pile	6
Collapsing of the pile head due to non-using a cushion to absorb the driving energy	7
Problems due to site conditions such as railways adjacent the site	8
Poor arrangement for piles precedence execution	9
Environmental problems due to driving such as noise or steam	10
Stopping during driving a certain pile	11

CONCLUSION

The main aim of this paper is to analyze the various risk factors affecting the activities of (DPRCP) based on qualitatively approach. The analysis is conducted throughout identifying the most important factors that be considered when quantifying the effect of these factors on cost and time objectives. With assistance of a designed practical survey, the factors affecting Driven Piles activities in the Egyptian construction industry are identified and assessed in this work. The results showed that there is an excellent agreement among the contractors, consultants and owners in terms of ranking and prioritizing the risk factors. In term of importance and Based on results and analysis, the following conclusions can be drawn as presented below:

- The Risk Breakdown Structure (RBS) for risk factors affecting the activities of (DPRCP) is developed for risk identification purpose. It helps the dealers with these projects for preparing the risk register form.

- ‘Poor materials quality’ and ‘Using inappropriate tools’ are the top-ranked risk factors affecting the activity of ‘Preparing and casting piles’ while, ' Inappropriate casting method' and ' Piles arrangement and number of piles in the casting and curing area' are the lowest risk factors in their rankings due to this activity.

- ‘Poor system of fixing pilling machine’ and ‘using inappropriate surveying devices to steer the pilling machine’ are considered, according to the respondents, the most influential risk factors to ‘Positioning piles and steering the pilling machine’ activity. On the other hand,' Extreme weather conditions' and ' Characteristics of the waterway section such as channel width and water velocity' risk factors can be considered with low importance.

- According to the importance of the risk factors affecting activity 'Handling piles', 'Lack of specialized equipment's' and 'Handling the pile in an unsafe manner' seems to appear the most important risk factors affecting this activity. As in previous activity, it can be referred to risk factors ' Extreme weather conditions' and ' Characteristics of the waterway section such as channel width and water velocity' with low importance.

- Risk factors under the purview activity 'Driving piles' are 'Differences between soil boring report and the soil nature' and 'The machine or the pile is not vertically'. On the contrary, the risk factors with lowest importance under the purview of this activity are ' Stopping during driving a certain pile' and ' Environmental problems due to driving such as noise or steam.

Finally, the analysis and findings in this research work present valuable data for the Egyptian government and local partners to have an in-depth understanding of the risk factors affecting Driven Piles Activities in the Egyptian construction projects. Such understanding is very important for implementing further effective measures to ensure the right direction of future development and create a more attractive market to these types of projects in Egypt.

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