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A process-based framework for modelling risk-related failure costs in construction

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Abstract

In construction projects the occurrence of any risk-related event often yields extra time and cost, which is sometimes referred to as failure costs. Research studies on failure costs suggest that a significant part of construction costs are unnecessary and can be avoided in most cases. The studies suggested as well that a large proportion of failure costs are related to unattended risks and process related problems. To deal with this problem the work presented in this paper describes the development of a proposed process based framework for risk assessment in construction. The proposed framework considers that construction works can be modelled as a process that contains a set of construction activities and that risks may occur at activity level as well as at process level. In this paper the proposed framework is applied to building foundation works but, in principle, it can also be adapted to be applied to any type of construction work. Initial evaluation of the framework by experts interviewed confirms its usefulness to allow a better assessment of risks and their influence on the overall process performance as well as occurrence of failure costs.

Keywords: Failure costs, risk modelling, risk identification, construction process, process performance

1 Introduction

Construction projects are inherently risky. Various types of risks can occur at different stages of the construction process. It is during the construction or the operation stages however that risks are more likely to materialise (Barber et al., 2000). The occurrence of any risk-related event often yields extra time and cost (Imbeah and Guikema, 2009), sometimes referred to as failure costs. Such failure costs are highly recurrent in construction projects (Baloi and Price 2003; Frimpong et al. 2003; Josephson et al. 2002), which have led many practitioners to accept them as being inevitable in any construction project (Kazaz et al., 2005). Others argue that project complexity facilitates the occurrence of failure costs in the construction industry (Aoieong et al. 2002; Zeng et al. 2007). In-depth analysis into the sources of failure costs however suggests that a significant proportion of these unwanted costs can be in fact avoided in most cases (Love and Josephson 2004; Love and Irani 2003).

Some previous studies have found that a large proportion of failure costs is the result of unattended risks and / or process related problems, see Chapman (2001) and Avendano Castillo et al. (2009) respectively. Unattended risks include risks for which insufficient or no analysis at all was carried out. It has been suggested that an adequate assessment of risks will enable the establishment of preventive and mitigation measures to reduce their likely occurrence and potential consequences in the form of failure costs (Smith, 1999). In reality however the assessment of risks is often poorly or marginally carried out in construction projects leading to unattended risks (Chapman, 2001). A recent study, carried out in the Netherlands on the quality failures and related costs in 40 cases of real building projects during the construction of foundation works, has found that unattended risks were the causes of failures in 62% of the cases (Tol, 2007). In another more recent study, it was found that up to 80 percent of failure costs in any given project are due to process related failures; see Avendano Castillo et al. (2009).

The work described in this paper aims to contribute to the efforts of failure costs reduction by developing a process based framework for identification and modelling of risks in construction. The paper starts with description of the proposed framework followed by the discussion on specific application of the proposed framework for analysing the construction process of a building foundation pit. The proposed framework is still in its initial stage of development, however the paper provides information on the elements of the framework and how it is used as a basis for modelling construction process risks.

2 Proposed process based framework for risk modelling

Risk management process is often carried out in stages and although there seems to be no agreement on the number of stages to describe it, there are nevertheless basic common stages that are found in all sources in the literature. These are the identification and classification of risks; analysis of risks; risk response; and risk monitoring (Smith 1999; Winch 2002; Zou et al. 2007). Chapman (2001) divides project risk management into two main stages: risk analysis and risk management. The stage risk analysis comprises the identification, classification and actual analysis of risks, and risk management stage comprises risk response and risk monitoring. According to Chapman (idem) current focus of project risk management is heavily orientated towards the techniques used in the management stage and that less attention is normally paid to the identification of risks. The underplaying of the initial stage of project risk management allows risks to remain unidentified and therefore unmanaged, i.e. unattended.

2.1 Process related problems in construction

At the beginning of construction, the manger will normally decide on the construction method perceived to be suitable for carrying out the work based on previous experience. This process will involve defining and planning of activities taking available resources and project constraints into consideration. Once the plan is drawn, it will form the project baseline in terms of cost and time. In theory construction works should follow the plan laid. However in practice this often not the case because the plan is often adjusted or changed as the project progresses due to problems related to uncertainty and risks encountered.

In practice, there is a tendency to merely rely on judgement and experience in choosing the construction method to be used for carrying out the work (Flanagan, 1993). Although such choices may prove to be right in some cases, the approach however does not take into account other feasible alternatives that might produce more favourable results in terms of reducing potential risks. A construction process is composed of a set of activities, each of which may be carried out using a number of different construction methods. This means that for any construction process, the number of possible alternatives will be dependent to the number of possible combinations of activities and methods whereby each alternative will perform differently in terms of cost and time (See Figure 1). Moreover the risks affecting each alternative may be differing in each case. The possible large number of alternatives and the interaction between the various activities and the risks to the project as a whole make the process too complex to be analysed manually even by experts with very long experience.

This work proposes a framework that will be used as a basis for a computer simulation model that takes into account the complex nature of the construction process described above in order to be able to identify the effects of using various construction methods on the reduction of possible failures. In this framework the construction works of a project or part of it can be modelled as a process that contains a set of construction activities and in which risks may occur at both activity and process levels. For this reason risks are categorized into two types, activity based and process based. Activity based risks are those that only relate to an activity and which may will affect its performance in terms of cost and time. The process based risks are those that, once materialized, may affect other activities as well as the process as a whole.

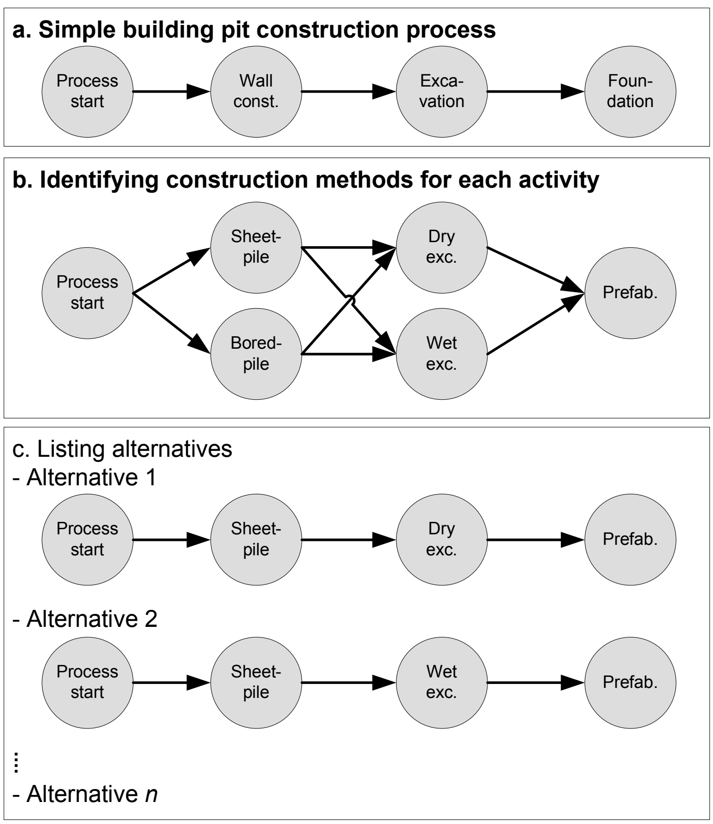

Figure 1. Example of a construction process with respective activities and methods

2.2 Elements of the framework

The proposed framework encompasses three stages. Figure 2 depicts a flowchart that represents the stages and elements of the proposed framework. The first stage constitutes the mapping procedure of the construction process. The second stage deals with risk identification at both activity and process levels. The third stage consists on the simulation module for the assessment of each alternative.

The purpose of the process mapping stage is to identify the different construction activities and methods applicable in a particular type of construction. The data collection instrument proposed is face-to-face interviews with experts. The framework consists of several steps in which the process of any type of construction work can be defined and alternative sequence and methods are established. Activity and process based risks are then identified and their influences are determined. Information regarding the cost and duration distributions of the activities and the process will then be used to perform Monte Carlo simulation to determine which alternative provides minimum risks and related failure costs.

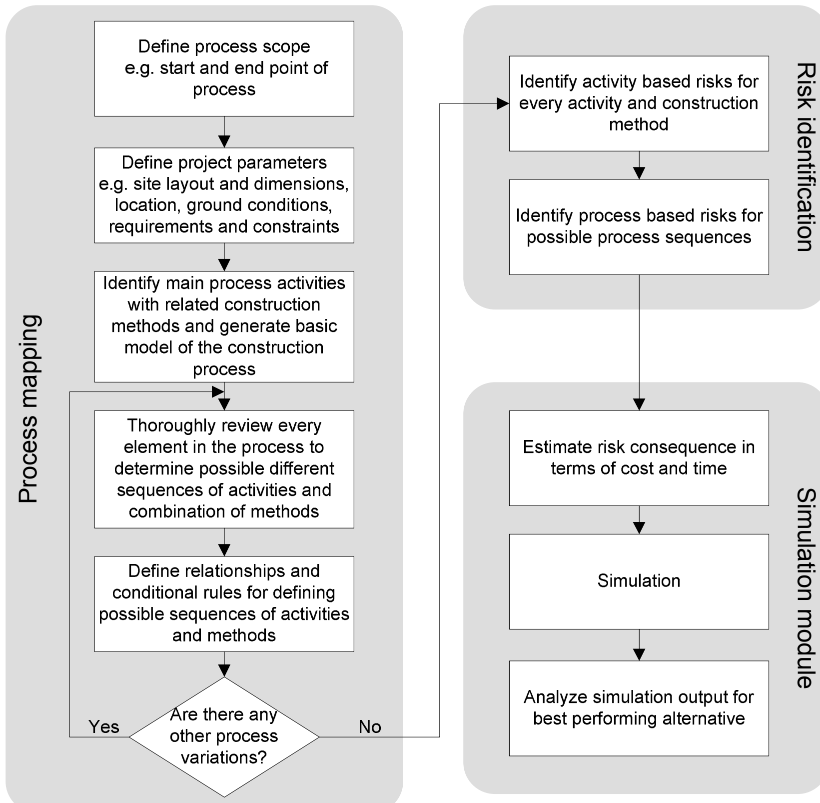

Figure 2. Process based framework for modelling risk-related failure costs in construction

3 Application of the framework

The proposed framework has been tested by applying it to model and analyse the construction process of a building foundation pit. A limited number of experts were selected and interviewed, based on their long experience in this type of work, to map and define the activities related. The research method used consisted of carrying out interview in a two phase approach, one phase for each of the first two stages of the framework. The reason for this was because at the end of the first stage acquired data were processed to allow proper feedback to improve the data collection forms used in the following stage. All the interviews were semi-structured. An example of data collected related to the activities and the different construction methods for the construction process of foundation pit is shown in Figure 3.

For the identification of activity based risk, a short list of the most recurrent risks for each construction activity was extracted from the literature. During interviews with the experts they were asked to validate this list. During the course of the interviews some of these risks were agreed upon while some others were omitted for not being relevant. Few additional were added to the list of activity based risks. After finalising the activity based risks list, a matrix form was used to establish the risks associated with each construction method. The experts were asked to identify the risks that are heavily dependent on the sequencing of the activities. Some of the most recurrent risks identified as being related to the activity sequencing process are shown in Table 1.

After carrying out just few interviews it was possible to see that there was some consensus amongst the interviewed experts on the suitability of the produced model of building pit construction and that the fact that it contains the major components of the process. The other aspect the experts seemed to agree about was the list of identified risks produced.

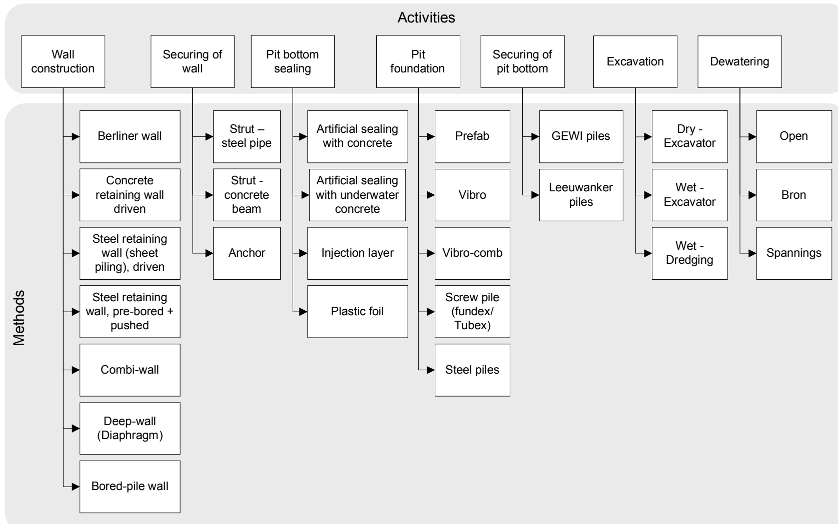

Figure 3. Construction activities and methods identified by foundation works experts.

Table 1. Process related risks identified by foundation works experts.

Code name	Description
fou_damage_exc	Damage to the foundation elements due to excavation works. This problem is likely to occur when the excavation activity is carried out after installing the foundation piles. The problem consists in damaging the head of the foundation piles with the excavation equipment while excavating.
wall_deformation_exc	Deformation of the wall while the excavation works are being executed. This problem is likely to occur when the dry excavation method is used. This method may triggered a wall deformation because of change in the horizontal load balance produced by the removal of material from the pit.
wall_deformation_dew	Deformation of the wall while carrying out the de-watering of the building pit. This problem occurs when pit requires to be dry out after a wet excavation. Due to a change in the horizontal load balance during the dewatering, a section of the wall may shift from its original position.
set_surroundings_wall_def	Settlement in the surroundings triggered by the deformation of a wall element or section. This problem is likely to occur when the deformation on a section of the wall has taken place.

4 General Discussion and Conclusions

The construction industry has been constantly criticised for not being able to deliver projects within their targeted budgets and time. In many cases this is seen an indication of inefficient processes that produce failure costs. Previous studies on failure costs have provided evidence that a significant part of these failure costs is due to unattended risks and process related problems. Unattended risks may result from inadequate risk identification process. Furthermore current practical approaches in selecting the construction method is not suitable to consider the complexity of the construction process and all possible combination of alternatives that may exist. The framework proposed in this paper is a computer system that allows the assessment of risks for all feasible alternatives that can be used to carry out the work and assist the managers to identify the one with minimum risks. By doing so it supports risks identification effort through consideration of the intrinsic complexity of the construction process.

The framework has been applied to identify risks affecting the building pit construction process. By following the proposed steps, it was possible to map the process and identifying all main activities, possible sequences and methods that can be used. In addition to this, it was possible to identify activity and process based risks that may result in failure costs. Albeit limited, the number of interviews conducted with foundation construction experts has confirmed the usefulness of using the framework for eventually selecting a more efficient construction method.

4.1 Further work

The work described in this paper is part of a larger research project that aims to use the model produced by the framework for various construction operations to simulate the effect of using alternative construction methods on the reduction of failure costs, particularly those triggered by process based risks. The data that has been collected by means of the application exercise referred to in this paper will serve as initial input to the simulation model that is being developed for this purpose.

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