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RISK MANAGEMENT IN CIVIL CONSTRUCTION PROJECTS – FROM COST ESTIMATING PERSPECTIVE

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ABSTRACT: Construction projects are full of risks. This is particularly the case in civil construction projects that are often featured with large scale, complexity and involving a large number of participating parties. The eventuation of risks typically results in extended project durations leading to an increase in the total project budget. The consequence can be amplified considering the significant impacts of civil construction projects on the society, from economical, environmental and social perspectives. This research investigates the significance of risks within civil construction projects and approaches to deal with risks. Semi-structured interviews were undertaken with local industry practitioners in South Australia on this matter. It is found that the industry is fairly aware of risks associated with civil construction projects and subsequently has procedures in place to attempt to minimize the impacts of these risks on the project outcomes. The interview results also indicate that there is limited utilization of software for the risk management purpose from the cost estimation perspective.

Keywords: risks, risk management, strategies, cost estimating, civil construction, South Australia

1. INTRODUCTION

The construction industry has a reputation for being very poor in the identification, assessment and management of project related risks, resulting in projects that frequently endure cost blowouts and exceed their expected completion dates [1]. The civil construction industry in particular, has been found to be subject to these problems with cost increases occurring in as many as nine out of ten transport infrastructure projects [2].

In recent years, numerous cost blowouts have been reported throughout Australia. Some recent examples include South Australia's Northern Expressway, Queensland's Springfield Rail Project, Western Australia's Perth to Mandurah Railway Project and BHP Billitons's Ravensthorpe Nickel mine. Each of these projects has reportedly seen significant increases in either their actual or final estimated construction cost when compared with the price that they were initially estimated to cost [3-5].

A major reason for this high proportion of cost blowouts is that the industry is subject to a wide range of risk factors and events that can affect the final cost of the project. These risks includes some relatively unpredictable factors such as inclement weather; the productivity of labor and plant; inconsistencies in the price, quality and availability of materials; and a range of other risks that are internal to the companies that undertake them [6]. Making adequate provision for such risks during the cost estimation phase of the projects is complicated, due to the difficulty associated with identifying, quantifying and making allowance for their possible occurrence into cost estimates. This is particularly difficult during the early stages of a project when many details such as the scope, site conditions, the project's commencement date and duration of the project are yet to be determined.

This research aims to identify the various risk management tools and methods that are being employed by South Australian civil construction companies and other organisations associated with the development of cost estimates/tender submissions for these projects, along with the extent to which these tools and methods are being used.

2. LITERATURE REVIEW

2.1 Significance of the issue of inaccurate cost estimation

Factors such as project cost escalation are of major concern to all parties associated with the planning, construction and ownership of construction projects, as this ultimately results in increased financial outlays by one or more of the parties and therefore reduced income or profit from having undertaken the work. The high frequency of increased project costs seems to have resulted in their acceptance as the norm rather than the exception in the delivery of civil infrastructure [7].

It is critical to have the accurate definition of project scope, risks, timelines and the need for cost estimation that is based on reliable cost data. However, reliable cost data can often be difficult to obtain and, therefore, apply in the early stages of a project due to many details such as basic design and layout often being unresolved. Despite this, it is not uncommon these early project cost estimates become contracts which are then translated into budgets,

subsequently resulting in the estimated value provided early on in a project becoming the amount for which the project is required to be delivered [8]. Flyvberg at al. found that the underestimation of costs at the time of the decision to build was the rule rather than the exception for transport infrastructure projects, often leading to substantial cost escalation for the project when compared with the initial estimates for its construction [9].

Although not typically the case, Odeck suggests that ideally studies or reviews of projects should be undertaken upon their completion in an attempt to understand why differences have occurred between the estimated and actual costs, with the results recorded in a way that assists in the improvement of cost estimation of future projects [10]. The use of a process such as this not only allows for the identification and analysis of what went wrong within the project but also assists in implementing measures on future projects to ensure that the same mistakes are not repeated. Unfortunately these reviews are not common and therefore the reasons behind many project failures or even the measures used to manage particular risks are not recorded. Mullholland & Christian found that there are a number of reasons why such information often fails to be recorded including the consideration by the team that the project was unique and therefore information from the project would not be required in the future, a lack of interest or funding being available at the end of a project to complete a review of the project or that no formal or convenient process was available to the team to undertake this form of review [11].

2.2 Common sources of risks in civil construction projects

A wide range of risks and uncertainties are always present in construction projects and these often result in project delays or cost overruns being experienced [12]. Regardless of the size of the project, it is inevitable that the factors of risk and uncertainty will be an important factor that must be considered and addressed [1].

The following categories of risks are identified to be applicable to civil construction projects [6, 13]:

- Planning risks: such as the ability to gain development approval and building approvals that may be critical in determining when site works can commence and exactly how a site can be developed
- Contractual risks: such as flawed contract documents or improper contractual relationships
- Financial risks: such as the owners inability to adequately finance the construction of the project
- Management risks: expertise of contractors and clients
- Site related risks: such as the actual site conditions and their variability from that which was anticipated during the cost estimation and program development process
- Performance risks: such as the need for rework due to either mistakes or a poor standard of work being completed by the builder or his subcontractors
- Political risks: such as changes to laws or regulations that the project must comply with and the subsequent need to alter the project during the design and possibly construction stages to meet these changes
- Internal risks: such as a lack of staff, inadequate training or experience of staff, financial constraints or a lack of support from management teams

Another factor that can affect the accurate cost estimation of construction projects is a lack of Estimator involvement. Lukas noted that while typically Estimators are involved in the early stages of a project, often they are not given the opportunity to review the costs associated with completing the project until the later stages of the design phase or sometimes until there is a problem during the construction stage [14]. Other factors that may affect the accuracy of these early estimates include factors such as variations to the scope of work and additional contractor claims due to other conditions altering from that which was stated or provided within the contract documents [15]. Because of these frequent changes, it is essential that estimators document all assumptions and/or exclusions associated with the estimates that they provide, so that it is clear exactly what has been allowed for within the price that they have developed.

2.3 Risk management software in construction industry

Software programs that can be used in the identification, assessment and management of risks and are considered as either being applicable to or currently used by the construction industry include: @RISK, Predict, Precision Tree, Analytica and KnowRisk. A number of other computer based systems that are capable of identifying, analysing and managing risks during the literature review, including Code Optimisation [1] and Casper [13].

A number of the Internet based project management systems such as Acconex and Project Centre were also identified. While these programs claim to be suitable for risk assessment, their use in terms of risk management is related more closely to the construction phase rather than the cost estimation phase of civil construction projects and therefore these forms of software have not been considered as being applicable to this research.

In short, these software programs appear to essentially mimic the ‘manual’ methods for risk assessment techniques such as Monte Carlo simulation, Decision Tree and Influence programs. This is not surprising as the manual methods each explain a process that would appear to take considerable effort in terms of either recalculating the probability of particular risks occurring or the illustration of project events/items and their associated risks and dependencies. Obviously the application of computers to these tasks not only allows for increased speed and accuracy in undertaking risk assessments, but also provides the ability to manipulate and compare slight variations within the proposed management of risks.

3. RESEARCH METHODOLOGY

Semi-structured interviews were undertaken in order to understand the industry practitioners' views on the significance of risks associated with the cost estimation in civil construction projects and approaches to deal with risks. 15 interviewees were selected from a range of civil construction companies, quantity surveying firms and project management firms in South Australia, along with both state and local governmental departments. The key selection criterion is that the participants should have the knowledge and experience in risk management and its application to civil construction projects, in particular the cost estimation process.

Interview questions are designed to retrieve the following information:

- Perceptions of risks
- risk management practices in cost estimation process
- the application of risk management software in cost estimation.

4. DATA ANALYSIS

4.1 Perceptions of risks

There are a number of factors influencing perceptions of risks in civil construction projects. As shown in table 1, Financial liability to self or own organisation that may result from a particular risk eventuating is ranked as the most important factor that influences individual's perception if risks during the preparation of cost estimates or tender submissions. In addition, risks were generally perceived by respondents as being known and to some extent controllable whereas uncertainties were seen as things that the impact of which would be difficult to quantify generally being as the result of a lack of information about it. As one interviewee commented, "Risk is a scaled measure of potential events or conditions which may affect project outcomes e.g. excavation in a dry watercourse in summer can be assessed as low risk of inundation from a rain event however this would be a high risk in winter. Uncertainty is a lack of knowledge or information about a particular circumstance or condition to enable risk to be assessed e.g. excavation in an old quarry site which has been backfilled with a miscellaneous material, it may be clean, rock or contaminated fill". Losing key staff from the project team is identified as the major internal risk by interviewees.

Table 1. Factors influencing the perceptions of risks

Factors	Ranking
Financial liability to self or own organisation that may result from a particular risk eventuating	1
Experience in resolving similar issues on previous projects	2
Access to colleagues and/or other professionals experienced in the delivery of similar projects	3
Ability of site staff to effectively manage particular risks	4
Access to records of similar projects previously undertaken by the organisation	5

4.2 Risk management practices in cost estimation process

4.1.1 Risk identification

According to interviewees, the common practice to identify risks that may cause delays and cost overruns in civil projects are:

- Analysis of project by individual Estimator, Project Manager or other team member
- Formal or informal meeting(s) between estimating team members
- Brainstorming session of Project Managers and/or engineers
- Assessment of the project by experienced staff who may not necessarily have any further involvement in the estimation or tender submission

Respondents predominantly reported that the risk identification methods used by their organisation are the result of past success with the methods and their belief that involving a range of professional's perspectives was more likely to identify the wide range of risks because of the different skills, knowledge and experiences of each professional.

There is a mixture of responses to the question whether or not these methods are adequate for the determination of risks in civil projects. Of those who appeared to respond positively, the reasons cited included: projects achieving their budgets; that many projects have similar risk profiles and the current process used readily incorporates risks into tender cost schedules; system incorporates new information as it becomes available, ensuring process used develops as do the anticipated risks; current system is a tried and tested method. Those who responded negatively gave the following reasons: hard to assess accurately the likelihood and consequence of particular risks: things still happen during projects that were either not identified or were not sufficiently allowed for; current system provides a basis however there is still the need for a rigorous dependable process; project always have unknown risks, some of which will not be identified.

4.1.2 Risk assessment

Interviewees were asked to nominate the groups or individuals within the organization that are responsible for the assessment of project risk. Most interviewees nominated estimators and project managers to take this responsibility. In addition, inputs from operations manager are required if a specific technical / construction technique is identified. The methods to assess the likelihood of particular risks eventuating are shown in table 2.

Table 2. Methods to assess the likelihood of risks in civil projects

Formal methods	Informal methods
• Use of spreadsheets	• Reflecting on experience

and/or checklists to record and document the perceived level of risk • Drawing up of risk management plan • Integration of risk matrixes – high/low cost impact, quality or time impacts • Value management and value engineering sessions • Using available site information to provide calculated basis for risks • Risk management sessions or workshops	and historical records • Holding informal meetings with no set risk strategy • Having a thorough understanding of the project and the potential risks • Good communication and willingness/openness to discuss risk and mitigation strategies • Commitment to process and regular review

Interviews found that there are a number of methods to assess the impacts of risks in civil construction projects. As shown in Table 3, inclusion of a contingency being a dollar amount is ranked as the most popular method to assess the consequence of risks in civil projects. Interviewees subsequently commented that the following methods as the alternative options to reduce the impacts of risks:

- Projects with higher risk usually have a higher margin applied to them – company would rather not win a project than win it with a low margin
- Percentage based contingency not typically used as it is considered too broad
- Percentage based contingencies used against individual items that may be considered as being project risks e.g. high risk of hard rock and therefore a percentage based contingency applied against this item

Quantity surveyor interviewees typically detailed that they would attempt to mitigate risk issues during design and documentation phase, suggesting that while this may cost more upfront it is likely to reduce the level of risk and result in savings for the client over the longer term.

Table 3. Methods to assess the consequence of risks in civil projects

Methods	Ranking
The inclusion of a contingency within the estimate/tender being the addition of a dollar amount based on the experience of one or more individuals within the organisation	1
Research of alternative options that may reduce or eliminate the level of risk involved and costs included within the estimate/tender for these alternatives	2
The inclusion of a contingency within the estimate/tender being the addition of a percentage mark-up based on the experience of one or more individuals within the organisation	3
The inclusion of rates within the estimate/tender from subcontractors with the intention that the risk associated with an item would be transferred to them	4

4.3 Risk management software and its application in civil projects

Only 33% of interviewees indicated that their organization has used formal risk assessment tools or software programs. Among them, four interviewees reported using the @risk software. The other respondent noted the use of an in house developed spreadsheet based on AS4360 where the Estimator uses predetermined categories as a guide to potential risk items, consequences or likelihood's are assigned to assess risk and make provision.

While not used by the particular respondent, one participant noted the use of a software program called 'Crystal Ball' that they suggested is used typically by mining companies for the identification and assessment of project risks.

Respondents who were using the @risk program described a similar series of steps in the use of this program to analyse risks, which are outlined below:

1) The system operates within Microsoft Excel
2) Firstly a schedule of items that form the basis of the project is produced and costed
3) Some of the items within the project are then identified as having a risk associated with them
4) These items are then given a most likely cost based on an assumed quantity and/or duration
5) A possible range of the cost being the low, most likely and high dollar value is then developed for each of the individual items identified as having risk associated with them
6) A distribution graph is then assigned to each of these items, with known risks given a triangular distribution and unknown risks given a truncated triangular distribution
7) This information is then entered into the @risk program which samples these risks and their effect on the cost by simulating the project occurring thousands of times (the actual number of reiterations is determined by the user) and graphing the anticipated likelihood of risks eventuating and the costs that would be associated with them

8) The software then produces a 'P' value (again as determined by the user), to demonstrate that if the project were undertaken for example 1000 times (the number of iterations set by the user) that the cost would most likely not exceed a particular value. For example a P90 value would indicate that there is a 90% probability that the estimated value given at this point within the distribution table will not be exceeded

According to interviewees, the key driver to make the decision to commence the use of risk assessment tools or software programs is that of clients (in particular State Government departments) requesting the introduction of a more stringent risk assessment and analysis processes. This request was noted as having been made due largely to the increasing size of projects being undertaken and the therefore increased amounts of money involved. This was particularly important for State Government respondents to this question who noted the need to lessen the impact of a shortfall of funds occurring on future projects, which if they were to occur necessitate lengthy submissions and justification as to why additional funds are required. Interviewees highlighted the key features that influenced the decision to introduce and use particular system(s) as:

- Ease of use
- Ability of outcomes to be incorporated into cost estimates
- Price of the tool or method
- Support and training available for the software
- Recommendation by others within the industry

Interviewees generally recognized the benefits of the introduction of these tools such as:

- Increased confidence that risks have been assessed
- Increased accuracy of initial estimates when compared with final costs
- Expansion of the services offered by the organization such as consultant estimating service
- Statistical analysis of completed projects can be used to assess future project estimate allowances

Respondents had mixed opinions on whether or not they would recommend their tool/program to other agencies. Opinions in favour of recommending the tools generally related to perceptions of increased cost accuracy. One of the reasons given for not necessarily recommending the tool/program were that the programs were more suitable for work being performed by the organisation itself rather than through managing subcontractors. Another respondent commented that the program that his organisation uses does not fit within the contractual framework within which most companies need to operate and that therefore it may not be suitable for use by some organisations. One interviewee particularly highlighted the need for users to have a thorough understanding of the process that the program uses. He noted that without an adequate understanding of the program and how it operates that the outputs provided are likely to be of limited accuracy.

The following issues are identified by interviewees as factors that inhibit the introduction of risk management tools or software programs in civil projects:

- Lack of knowledge of risk assessment programs
- Cost of program, implementation and staff training
- Budget rather than profit focussed
- Lack of understanding of probability/distribution of risk
- Transferring risks to others
- Reluctance to change/culture of the company
- Tools perceived as not being user-friendly
- Being able to prove the need for it

Interestingly, it was noted that those participants who had indicated previously that they were not currently using any forms of risk management software were the only ones who also indicated that 'the cost of the program' and 'a reluctance to change by the organisation' were factors limiting the introduction of such risk assessment tools and/or methods. This is in line with the findings of Smith et al.'s study that program users must have a good understanding of the effects of data entry or manipulation within these programs [16].

5. CONCLUSIONS

Cost escalation is a major concern in construction projects. Civil construction project is no exception. This research adopted a qualitative approach to investigate the risk management approaches employed in the cost estimation process of civil construction projects. 15 industry practitioners in South Australia were selected for semi-structured interviews. The results showed that a wide range of approaches exist within the South Australian civil construction industry for the identification and assessment of risks. It appears that no consistent method of approaching the cost estimation and risk assessment of civil construction projects exists, with this most likely being largely due to the large variation between the types of projects undertaken, the risks involved, the value of the projects and the experience of these organisations and their employees.

The interview results also showed that risks to these forms of project are well understood and that the majority of organisations represented have methods in place to consider the various risks associated with these projects, it is also clear that the majority of them are not making use of the technology that is available to in the form of risk management software. Subsequently, there is considerable scope within the South Australian civil construction industry for the inception of suitable software programs and training in their use.

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