Construction Contingency Determination: A Review of Processes and Techniques

Richard Emeka Adaurhere [1], Innocent Musonda[2], and Chioma Sylvia Okoro[3]

[1] Engineering Management Department, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
[2] Construction Management and Quantity Surveying Department, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa
[3] Finance and Investment Management Department, Johannesburg Business School, College of Business and Economics, University of Johannesburg, South Africa
corresponding-author-chiomasokoro@gmail.com; chiomao@uj.ac.za

Abstract. Contingency provision on a construction project is one of the risk management techniques embraced by project owners to deal with project unanticipated expense (spending) and time overruns. However, contingencies could be overestimated or underestimated. The current study therefore investigated how contingency is determined on construction projects and the benefits of contingency planning. A literature review of literature was undertaken from various databases including Academic Search Complete, Google, Goole Scholar, Ebscohost and others. The materials used were selected based on their possession of the key words related to the study. Thematic content analysis was used to identify themes on cost and time contingency planning process and techniques. The findings revealed that the process of cost contingency determination entails identifying different scenarios of events and risks, and developing the plans based on the potential responses to the identified risks. Further findings revealed that various techniques may be used in the process and practice of estimating cost and time contingencies. The findings are envisaged to be beneficial to construction stakeholders assess and improve on contingency planning process on projects.

Keywords: Construction, Contingency, Planning, Project management

1 Introduction

The construction industry contributes to the gross domestic product (GDP), employment and capital formation in an economy [1]. The sector is the biggest industrial employer recording to around 7% in many nations and making up around 9% of the world's GDP [2]. However, most often, construction projects overall make a nationwide headline for being a financial disaster as opposed to the accomplishment of the critical engineering contribution that it adds to the improvement of our built

environment [3]. Construction projects are faced with various risk and uncertainties, including conceptual cost estimation [4]. The construction industry had thus gained a poor reputation for delivering project over the estimated budget and time plans. Due to the numerous risks associated with project deliveries, project owners tend to make provision for contingencies, as part of the costs at the planning stage, which are able to absorb monetary impact risk/uncertainty and variability. These contingencies can be in the form of (money, time, quality specification, man-hours, machine-hours, and raw materials), which are put in place to ensure that the project objectives of time, quality and scope are not jeopardized due to any unforeseen risk that might arise during project execution. Contingencies are planned in order to hedge and absorb these risks [5]. However, construction projects hardly live up to the plans because of the risks related and the general vulnerable and stochastic nature of construction projects [6]. These risks should be recognized and overseen in the planning stage. This is even more important given the complex nature of construction projects with hidden and apparent costs. Therefore, research on how contingency amounts are determined and the benefits of contingency planning in construction projects warrant attention.

Previous similar studies on contingency planning have dwelt on schedule delays and plan contingency [6] or on the techniques and did not include the process of contingency planning [7]. Further, [5] investigated management of contingencies among Spanish contractors and found that about half of the site managers do not typically include time and cost buffers in their budgets and schedules and when contingencies are established, it is usually done in a subjective manner. However, the study did not reveal the processes undergone or the factors considered in contingency planning. Other studies which considered factors affecting contingency determination employed risk analysis and fuzzy logic system (incorporating subjective notions of contractors) [8], [9]. The objectives of the study were therefore to investigate the processes and strategies for contingency determination and the pros and cons of inadequate contingency planning. The findings of the study are significant because if projects are delivered without adequate determination and management of contingencies, they may not perform as planned. The succeeding sections of this paper present the findings from a literature review on the factors that should be considered in the contingency planning process, irrespective of the various stakeholder views.

2. Methods

The present paper presents a review of literature based on international context with the aim of identifying how contingencies are determined and the benefits of adequate contingency planning. To achieve this objective, a distillation of related literature from online databases including Google, Google Scholar, Ebscohost and Science Direct, was undertaken. Various sources including accredited journals, conference proceedings and organisation websites were consulted. The materials used were selected based on their possession of the key words related to the study, including contingency planning, risk management, construction contingencies, and project management. Thematic content analysis was used to identify themes on contingency planning influencers and

considerations. The succeeding sections present the review of related literature on the themes, summary of findings, conclusion and recommendations.

3. Construction Contingency Planning

3.1 An overview

Construction projects are typically a once-off endeavour with numerous unique features, for example, different project members, long maturation periods (between origination-design construction), composite acquisition procedure, huge fiscal requests and dynamic organization configurations. All these have made the risk and vulnerabilities identified with construction projects more peculiar as compared to other sectors. Though literature revealed that construction risk can't be disposed of, it can be relieved and overseen successfully. Thus if project risk and unprecedented attributes are recognized and measured at the beginning times of the project, this will ensure that all relevant project stakeholders (customers, experts and contractors) will strive to accomplish project goals of cost, time, quality and safety.

The success of construction projects, generally viewed as being completed on time, within the budget plan and the quality fulfilled by all, is charaterised as much preferred outcomes over the normal or ordinarily acquired. Nonetheless, the term project success is a foundation to manage and control the current project, in order to plan and orient the future project [10]. It assumes that things that cannot be estimated cannot be improved. This is the basis of adequate planning in construction project development. The planning and control of costs cannot be successful if the extenuations are not evaluated and planned for at the initial stage of the projects.

The term contingency, used in this document in a generic manner, is mainly employed by a number of authors to describe the amounts of money that budgets often include in order to prevent cost overruns related to unforeseen, unexpected or underestimated events [5]. However, there are various other forms of contingencies including time (buffers) to accommodate project delays, material stock piles buffers, work in process buffers, capacity (manpower, tools and equipment), plan buffers as well as scope and quality buffers [5]. According to [4], contingency is viewed differently but the various stakeholders in a project. To engineers, contingency is a savings account that can be drawn on to take care of the extra expenses of miscalculated or excluded project costs; to the construction division, it is an amount used to take care of extra expenses caused by longer schedules, construction issues, and lower profitability; to the cost engineer, it is an amount that can be utilized to take care of higher expenses because of the absence of definition at the evaluating stage, including miscalculation of material, gear, labour and indirect expenses. The two main types of contingencies are further discussed hereunder.

3.1.1 Cost contingency

Contingency cost is a reserve fund added to the total assessed project cost and often it is communicated in percentage terms [11]. “Cost” is alluded to as the level of fulfilment of construction work within the assessed spending plan. A project’s total cost is often broken down into two parts, namely: base cost and contingency cost. Base cost is the expense of the project which omits contingency. The total cost is not just bound to the tender sum, but incorporates any expenses that emerge from varieties, changes amid the construction time period, including impact of changes in the price of labour, material, plant, preliminary items and specialist subcontractors as well as costs brought about by lawful cases, for instance, litigation and arbitration [12]. This underlines the relevance of more accurate cost determination or estimation techniques at the planning stage of projects, to cater for project exigencies or unexpected occurrences from a reserve of funding termed “contingency”.

3.1.2 Time contingency

The term 'time contingency' is characterized as the measure of time added to the base assessed project time to accomplish a particular certainty level or to take into account changes where experience indicates commitment [13]. It can likewise be characterized as the measure of time put aside to manage construction vulnerabilities, risk of overruns of project goals to a satisfactory level [14]. Time contingency is viewed as a standout amongst the most basic instrument used in a construction project to foresee or to give a sensible time frame. Because of this reason, satisfactory estimation of time contingency will help towards to minimization of overspending plan and help to prevent completion delays in projects [13].

Contingency is utilized to guarantee the fruition of time of a project and all things considered gives a level of certainty that the planned duration be accomplished. Most managers and engineers depend on their experience of deciding on schedule and cost contingency [13]. On their part, [15] evaluated time contingency as 20% of the project period, while [16[presented an approach that joins network analysis incorporating flexible scheduling in risk strategy and plan analysis due to changes as a result of the complexity of construction projects. The study [16] examined the impact of different factors on time contingency utilizing a linear equation. Further, [17] expressed that in the industrial division, there are numerous project scheduling programming, for example, Primavera and Microsoft Project; in any case, the most prominent is Risk Expert. This is on the grounds that it gives quantitative and qualitative examinations of project data, which is utilized to give a clearer image of the genuine expense and time size of any project considering risk, punishments, and complex scheduling factors.

These varying views therefore make it difficult to determine the amount to be set aside for contingency on a particular project. However, certain factors affect the determination or planning for contingency in order to deal with unanticipated expenses

and spending overruns, which are not considered or satisfactorily took into account at the planning phase [18]. This is the premise of the current study.

3.1.3 Material and labour contingencies

Related to the costs of construction are project resources such as material and labour required to successfully complete a given project [19]. Considerations made at the time of concept and planning of projects should include these which may constitute risks in building projects [20]. Hence, in preparation of bids, estimates should include thorough assessment and planning for project resources.

3.2 Benefits of contingency planning

Contingency planning helps to ensure that response is composed in light of the fact that objectives, procedures, roles and duties are cleared up ahead of time [21]. In addition, [22] added that the benefits of contingency reserve in a projects are as follows:

- This reserve fund is important to guarantee smooth fulfilment of design and construction, with no risk to the project caused by an absence of accessible funds.
- The contingency amount put aside as a cost contingency in the project is a component of the cost risks related to the project at that time.
- The incorporation of contingency amount on a project spending plan mirrors the by and large budgetary plan that will be utilized to cover known and unknown components of the projects.
- The value and assessed risk of a project change over its lifecycle. For example, the best pre-construction planning will greatly reduce contingency reserve.
- Contingency reserve for design will reduce from the concept design stage to contract document stage.

Undoubtedly, contingency planning guarantees accessibility of standby resource and provides an effective mechanism that can help reduce project disaster response [23].

3.3 Contingency planning process

According to [24] and [25], the contingency determination process, as depicted in Figure 1, entails an identification of scenarios of events, determination of imminent risks, developing responses to the identified risks and thereafter, developing a budget to cater for the risks identified.

The first step in the planning process is identifying scenarios of events and having records or rundown of conceivable courses of events that could happen, which forms the reasons behind planning presumption. Notably, scenarios are important scope of conceivable issues and its probabilities, for instance, what planners think could happen, how to work around such issues, what conditions individuals will confront, what effect will the risk will have and what limit individuals should adapt to in such an event, how well to be prepared ahead of time. Developing scenarios is a good way of thinking through the possible impacts, on which basis one can develop a plan that sets out the

scale of the response and the resources needed [21]. Therefore, scenarios being the foundation of the contingency plan, it likewise contains the principle planning assumptions used for the development of such a plan [24].

The second step is detecting the imminence of risk. This alludes to the probability of the recognized risk happening and assessing the level of potential harm (Bridges, 2014). Once the risk has been recognized they ought to be recorded within contingency plan and monitored [25]. The risk is categorised by the probability of their occurrence [25]. In addition, the impact or severity and distribution of those risks are quantitifed [8].

The third step is developing effective responses to the events are the activities required by the risk manager to relieve misfortune should the distinguished risk happen [25]. It is suggested that event managers conduct an experimental run of responses created to oversee recognized risk situations, therefore it will guarantee that they can deal with the management of contingency plan [25].

Lastly, a contingency budget and schedule plan is created and all required will be reliant on the size and unpredictability of the project. For example, most organisations usually add 10 % - 15 % to the base cost for all contingency related expenditure. In addition, it ought to be noticed that while some contingency planning are broadly detailed, others are short and unreal [26]. Nonetheless, planning for contingencies should incorporate all the factors that potentially affect estimated costs, time and related uncertainties in order to ensure that a project is completed successfully.

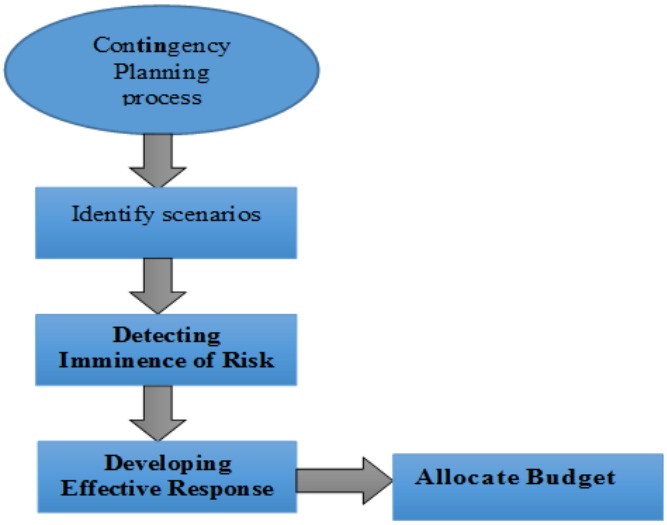

Figure 1. Contingency Planning Process (Source: Bridges, 2014)

In the view of the IFRC (2019), the contingency planning process is an iterative process that involves developing plans, reviewing and refining plans (Figure 2). In addition, it should be a collaborative effort on the part of all stakeholders involved in the project.

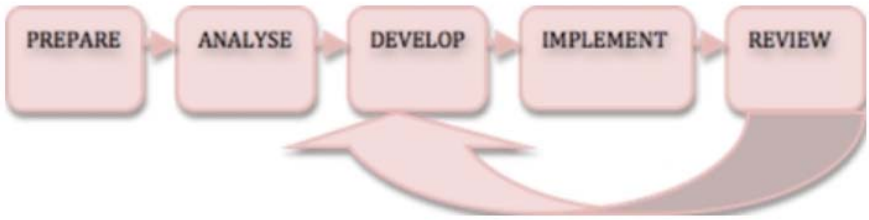

Figure 2. Steps in Contingency Planning (Source: IFRC, 2019)

3.4 Contingency determination techniques

According to [27], the methods used to estimate cost contingency in most construction industries are traditional, qualitative, semi-quantitative, probabilistic, deterministic, and simulation-based techniques. The majority of contingency estimation methods available focuses on the initial estimate of time and cost contingency and the most methods used are the deterministic and probabilistic method.

Deterministic approaches are the most basic since they focus on estimating a general percentage of the base cost estimate to include in the budget or the schedule, while probabilistic methods focus on identifying risk and allocating them in an itemised way of time and money to cover the risk [28]. Further findings evinced the advantages and disadvantages of these cost contingency determination techniques [7], [13], [18] and [29]. These are summarised in Table 1. According to [7], a variety of techniques are necessary, given the major shortcomings of the traditional judgemental and arbitrary approach to cost contingency estimation, which includes the following:

- Being calculated as an across-the-board percentage addition on the base estimate, typically derived from intuition, past experience and historical data;
- It is usually illogically arrived at and thus may not be appropriate for the proposed project;
- Calculation is difficult for the estimator to justify or defend and the risk is either disregarded or handled in a discretionary way, and so percentage used is sometimes not justifiable; and
- It does not encourage creativity in estimating practice, promoting a routine and mundane administrative approach requiring little investigation and decision making.

Therefore, other methods including Monte Carlo simulation, range estimating, regression, artificial neural networks and others may be more suitably applied in certain types of projects that others. In summary, if project risks and unprecedented attributes, which cause (envisaged) vulnerabilities in the project, are recognized and measured at

263 the planning stage of projects, success in terms of cost and time control, will be
264 achievable.

265 4. Conclusion

266
267 The study sought to investigate the process and techniques for planning and
268 determining contingencies on construction projects. It was found that the process of
269 contingency determination involves identifying different scenarios of events and risks,
270 and developing the budget and schedule plans based on the potential responses to the
271 identified risks. Further findings revealed that various techniques may be used in the
272 process and practice of estimating contingencies. The current study provides
273 information, which is envisaged to be beneficial to construction stakeholders in
274 adequately planning and allowing for contingencies on their projects.
275
276 Since the current study was a literature review only, further studies are recommended
277 to determine how contingencies are allowed for on construction projects and the level
278 of usage of the identified techniques in practice, using alternative research approaches.

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280
281 **Table 1:** Contingency methods/techniques

	Contingency Methods / Level or area of usage	Advantages	Disadvantages
1	Traditional Percentage Method / Used on all project types	•Convenience and consistency •Subjectivity is expelled from the procedure by the utilization of a consistent percentage.	•Problematic for the estimator to legitimize the reason for the percentage utilized. •Does not support creativity in evaluating in practice. •The risk is either disregarded or managed in a discretionary way.
2	Method of Moment / Infrequently used	•The individual cost in the project has its normal values and variance. •The normal values and variance for all cost items are included in arriving for the overall project cost.	•Because of its mathematical foundation, it is extremely hard to use •Not reasonable for complex and large infrastructure.
3	Individual risk- expected value / Used in all project types	•It can model vulnerability as contingencies with particular probabilities can be examined for a better outcome.	•Recognizing the fixed and variable components of the project is in respect to the type and nature of the project. Regardless, it receives a conventional approach
4	Monte Carlo Simulation / Used in substantial capital projects	•The model identifies the result of risk identification and effect assessment which can be used to estimate Contingency.	•Monte Carlo evaluating method is frequently harder than the traditional strategy. •It is once in a while used as a part of the business. It does not specifically give data about the change of the measurable dispersion of the acknowledged net benefits.

	Contingency Methods / Level or area of usage	Advantages	Disadvantages
5	Factor Rating / Used in substantial capital projects	•This technique can be utilized to check the measure of contingency dictated by different strategies for assessing contingency sum. •Apart from the capacity to check the contingency sum created by different techniques, it is a strategy for foreseeing its own particular contingency.	•Picking the four determinants of the accuracy of the estimate is Seriously deficient. It might prompt high contingency if the estimator is incorrect.
6	Range Estimating / Construction road projects	It deals with hopeful and negative closures of estimation. It is more secure than the traditional strategy.	•It additionally receives a deterministic approach which makes it less precise compared with regression models.
7	Regression / All construction projects, mostly building	•These models depend on historical information of projects, they bring expert information to contingency setting without the requirement for a skilled expert on each project.	• It depends on historical cost information which once in a while may not be accessible. Tedious to assemble historical cost information.
8	Artificial Neural Networks / Roads projects, Oil and gas projects	The forecast precision of this strategy for contingency estimation outperforms that of the traditional technique	Appropriate for non-linear modelling of information. It contradicts the direct approach of regression and different techniques like the Monte Carlo.
9	Fuzzy Sets / Significantly on building projects; few highway projects	•It permits examination with small samples. •It uncovers relationship between result and illustrative factors	•It is difficult to build up a model from a fuzzy system. For this strategy to be utilized for successful contingency estimation, it requires more fine tuning and simulation before it is operational.
10	Controlled Interval Memory / hardly used	•The model is accommodated with different perspectives of the project it speaks to.	•The numerical structures make it hard to use since management and expert thinks that it's hard to understand.
11	Influence Diagrams / Multifaceted construction projects	•It helps to lessen extensive volumes of information that is fundamental to the decision making process.	•Like other probability Models.
12	Theory of Constraints	•The utilization of this model yields an achievable and immunized plan centred on the Critical path of the work that rules the project through to its execution.	•This strategy presumes cost Items are autonomous from each other. •This is not correct in a real life application.

References

1. Kraaz, J. A., Hampson, K. D. and Sanchez, A. (2014). The global construction industry and R&D. Ch. 2 In: *R&D Investment in the global construction industry*. Editors: Keith Hampson, Judy Kraatz, Adriana X Sanchez, pp.4-23. Routledge, London.
2. Horta, I, Camanho, A, Johnes, J, and Johnes, G. (2013), 'Performance trends in the construction industry worldwide: an overview of the turn of the century', Journal Of Productivity Analysis, 39, 1, pp. 89-99, E-Journals, EBSCOhost, viewed 24 June 2018.
3. Oppong, P. (2013). Determination of variance between project cost contingencies and overruns in Ghana. Thesis submitted for Master of Science at the College of Architecture and planning, Kwame Nkrumah University of Science and Technology: Ghana.
4. Jackson, G., (2012). Contingency for cost control in project management: a case study. Construction Economics and Building, 3(1), pp.1-12.
5. Ortiz-González, J. I., Pellicer, E. and Howell, G. (2014). Contingency management in construction projects: A survey of Spanish contractors. Proceedings IGLC-22, June 2014 | Oslo, Norway, p 195 – 206
6. Dos Santos, R. B. and Jungles, A. E. (2016). Risk level assessment in construction projects using the schedule performance Index. Journal of Construction Engineering Volume 2016, Article ID 5238416
7. Baccarini, D. (2004). Estimating Project Cost Contingency: Beyond the 10% syndrome. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.622.2969&rep=rep1&type=pdf Accessed 01 April 2019
8. Panthi, K., Ahmed, S. M. and Ogunlana, S. O. (2009). Contingency estimation for construction projects through risk analysis. International Journal of Construction Education and Research, 5(2): 79-94
9. Idrus, A., Nuruddin, M. F. and Rohman, M. A. (2011). Development of project cost contingency estimation model using risk analysis and fuzzy expert system. Expert Systems with Applications, 38: 1501-1508
10. Chovichien, V. and Nguyen, T.A. (2013), "List of indicators and criteria for evaluating construction project success and their weight assignment", 4th International Conference on Engineering Project and Production.
11. Bakhshi, P. and Touran, A., (2014). An overview of budget contingency calculation methods in construction industry. *Procedia Engineering*, *85*, pp.52-60.
12. CIDB (2017). The drivers of the cost of public sector construction; assessment and recommendations. http://www.cidb.org.za/publications/Documents/Drivers%20of%20Cost%20of%20Construction%20Assessment%20and%20Recommendations.pdf Accessed 17 March 2019
13. Mohamed, D., Srour, F., Tabra, W. and Zayed, T., 2009. A prediction model for construction project time contingency. In *Chicago, Construction Research Congress*.
14. PMI (2000). A Guide to the Project Management of Knowledge (PMBOK Guide), Project Management Institute, PA, USA.
15. Park, M. and Peña-Mora, F. (2004). Reliability buffering for construction projects. Journal of Construction Engineering and Management, 130(5): 626-637
16. El-Karim, M. S. B. A., Elnawawy, P. and Abdel-Alim, A. M. (2015). Identification and assessment of risk factors affecting construction projects. HBRC Journal, 24. Doi: 10.1016/j.hbrcj.2015.05.001
17. Illsley, R. (2006). "Business Intelligence Pretmaster," Risk Expert, v7.8, Butler Group Subscription Services, New Jersey, USA.

18. Amade, B., Akpan, E. O. P., Ukwuoma, F. P. O. and C.C. Alajemba, C. C. (2014). Project Cost Contingency in the Nigerian Construction Industry. International Journal of Research in Management, Science & Technology, 2(2), 9-21.
19. Enshassi, A. and Ayyash, A. (2014). Factors affecting cost contingency in the construction industry: Contractor's perspective. International Journal of Construction Management, 14(3): 191-208
20. Lam, T. Y. M. and Siwingwa, N. (2017). Risk management and contingency sum of construction projects. Journal of Financial Management of Property and Construction, 22(3): 237-251.
21. International Federation of Red Cross (IFRC). (2019). Contingency planning. https://www.ifrc.org/en/what-we-do/disaster-management/preparing-for-disaster/disaster-preparedness-tools/contingency-planning-and-disaster-response-planning/ Accessed 01 April 2019
22. Hobbs, J., 2010. A methodology for setting contingency reserves using probabilistic cost risk analysis in small to medium construction projects. Word Count, 19521, pp.1-71.
23. Waterberg District Municipality (2014). Disaster management plan. http://www.waterberg.gov.za/docs/dmp/Waterberg%20DM%20Plan%202014.pdf Accessed 31 March 2019
24. Choularton, R. (2007), Contingency planning and humanitarian action; a review of practice. Number 59. Humanitarian Practice Network; UK: ODI.
25. Bridges, T. (2014). Exploring contingency planning for adverse weather conditions: how well do event managers plan for inclement weather? (Master's thesis).
26. Bello, W. A., & Odusami, K. T. (2009). Project Variables influencing Contingency on Construction Contract in Nigeria. RICS COBRA, 5(3), 34-36.
27. Ayub, B., Thaheem, M.J. and ud Din, Z., (2016). Dynamic management of cost contingency: Impact of KPIs and risk perception. Procedia Engineering, 145, pp.82-87.
28. Anderson, G. R; Mukherjee, A; Onder, N. (2009). Traversing and querying constraint driven temporal networks to estimate construction contingencies. Automation in Construction, 18(6): 798-813.
29. Hamid, R. A. and Kehinde, F. J. (2017). Choosing appropriate contingency sum estimating methods for highway construction projects in Nigeria. A literature review. Planning Malaysia Journal, 15(1).