Optimisation of the Project Cash Flow to Mitigate the Prolonged Negative Cash Flow

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Conceptual Formulation
Master Thesis for Mr. Hany Hawash
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Topic:
Optimisation of the Project's Cash Flow to Mitigate the Prolonged Negative Cash Flow

Background

it is palpable that negative cash flow is a worldwide phenomenon in the construction industry, as it is an integral part of the financial life cycle of any project, and its impacts may become so dire that a contractor needs to abandon a project. This is especially the case when it manifests itself as a financial burden on the contractors during the peak of the site activities when the project expenditures are much more than the payments received by the contractor. Consequently, myriad papers have been written to allocate and determine the reasons for the negative cash flow and its impact on the projects' success and completion. Thus, this research aims to analyse the leading causes and the mitigation measures and develop a manual for the contractors to follow in order to overcome the impacts of negative cash flow, which jeopardise the completion of the projects.

Research Questions

In light of the research objectives, the research shall provide answers to the following question:

- What are the causes of the negative cash flow?
- How often do the contractors face these events?
- How to predict a negative cash flow?
- How do impacts vary based on the phases of the project life cycle
- How to mitigate or eliminate the risks of the negative cash flow

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Methodology

The questions shall be answered throughout the research, starting with literature reviews of papers published regarding negative cash flow and its causes. Afterwards, a survey includes experts from all construction field disciplines, such as cost estimators, planners, project managers, site engineers, etc. Considering the survey, causes will be sorted based on the risk matrix, including the severity of the impact and likelihood of the occurrence. The risk management plan shall be developed for the causes with high severity of the impact and high likelihood of occurrence in order to establish guidelines and procedures that the project team can follow in order to mitigate these causes and risks. After developing the mitigation plan, I shall contact one of the companies to apply it to its previous projects in order to ensure the impact of the mitigation plan on the projects' negative cash flow.

After ensuring how beneficial the mitigation plan is for the project's life cycle by optimising the schedule and costs, the research will discuss the possibility of the automation of the mitigation process, as it will ease the process and enhance the proactivity of the project team.

Timetable

The research shall take place through four main stages, and each stage has its own products. These stages are as follows:

- Literature review: a literature review shall be conducted between February and March 2023. The papers, articles or previous research discussed in this stage shall cover the causes encountered by the projects' team from various locations in order to ensure that these causes are global ones and that the paper will be beneficial on a worldwide level.

- Survey: a survey shall be conducted between March and April 2023. The respondents shall represent various disciplines from the construction fields, such as cost estimators, planners, project managers, site engineers, etc. The survey's output shall include a risk management matrix for the causes mentioned above based on the severity of the impact and likelihood of the occurrence of each cause.

- Risk management plan: risk management plan for the causes with high severity of the impact and high likelihood of the occurrence shall be developed between April and July 2023. Such plan shall ensure that the risk is mitigated and the plan's impact on the schedule and cash flow of the project. A construction company will be contacted to share

two projects whose teams encountered any of the aforementioned causes during this duration. The developed mitigation plan will be applied to determine the impact of this plan on the projects' schedules and cashflows.

- Optimisation process: after applying the mitigation plan and measuring the impact of the plan on the schedule and cashflow of the project, the plan will be considered as an optimisation plan, and the optimisation process shall be automated in order to ease the implementation of such procedures and make sure that all project team members are able to understand the procedures and how to apply them in order to mitigate the impact of the negative cash flow with the most optimised schedule. This process shall take place between July and August 2023.

Resources:

Since the success of the research is attributable to several external factors such as previous papers, articles and research covering the same topic, respondents to the survey and a company sharing its data, the risk of the absence of any of the factors will be mitigated by expanding the range of the research in order to include companies and respondents from various countries like Finland, Germany, Egypt, Dubai, Saudi Arabia and other countries in order to increase the probability of meeting research requirements.

Library Website of the American University in Cairo: https://library.aucegypt.edu

Library Website of the Metropolia University: https://metropolia.finna.fi/

Google Scholar: https://scholar.google.com/schhp?hl=en&as_sdt=0,5

Survey Monkey: https://www.surveymonkey.com/

Computer Softwares

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Abstract

The construction industry contributes considerably to developed and developing nations' gross domestic product (GDP). In highly developed economies, construction contributes between 7 and 10 percent of value, while in developing countries, it contributes between 3 and 6 percent. Due to the significance of this industry, the paper investigated the three most common threats to the cash flow of construction projects, which is the lifeblood of any construction endeavour. The literature review and survey determined that the three most prevalent risks were delayed payment, inadequate planning, and underestimation during the tendering phase. In addition to concluding the risks through the literature review and the survey, the author was able to conclude the mitigation methods followed to mitigate these risks, which included bank loans, investing equity, and amending the payment terms to receive the payments earlier than the contractually agreed payment terms in exchange for a deduction for early payment. The case study illustrated the influence of these risks on the cash flow and the mitigation techniques implemented. Accordingly, the delayed payment had the most severe impact on the negative cash flow, while poor planning had the most negligible impact. The contractor was advised to invest a portion of the equity, which significantly improved the negative cash flow. However, amending the payment terms against minor deductions had the least impact compared to the other mitigation methods. However, these mitigation methods were based on the regulations and standards of Saudi Arabia, where the case study was conducted.

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List of Abbreviations

AIA	American Institute of Architects
BDM	Business Development and Marketing
BTO	Bill To Owner
CB	Cash Balance
CD	Cash Disbursement
CR	Cash Receipt
EJCDC	Engineers Joint Contract Documents Committee
FIDIC	The International Federation of Consulting Engineers
GDP	Gross Domestic Product
IS	Interest of the Saving
PCF	Project Cash Flow
PMO	Project Management Office
ROR	Return On Revenue
RR	Retained Reimbursement

1. Introduction

1.1 Background

The construction industry contributes significantly to developed and developing countries' gross domestic product (GDP) (Tse & Ganesan, 1997; Crosthwaite,2000). Lowe (2003) stated that the value contributed to construction is between 7 to 10 percent in highly developed countries and between 3 and 6 percent in developing countries. The construction value estimates added in developing countries could be more because of the unofficial sector, which could generate significant contingent employment in urban and rural areas, may not be included in the figures (Ganesan, 2000). The outcomes of the construction industry can be categorized as a significant portion of the investment and part of fixed capital. Both are necessary for sustained economic expansion. Construction projects require a long gestation period and are expected to provide service for a predetermined period. Since infrastructure investment is a precondition for future economic development, construction investments are paramount (Ive & Gruneberg, 2000; Hillebrandt). Considering the significance of the construction industry, this paper discussed the cash flow of the construction project, as the cash flow plays a crucial role in the life cycle of any construction project. In consideration of the significance of the construction field, this research examined the cash flow of the construction project since cash flow plays a crucial role in the project life cycle.

According to F. Lawrence Bennett (2003), a project's life cycle consists of six distinct phases, each with its objectives and characteristics. The proprietor must initially make several pre-project decisions, and the project's planning and design are then executed. Following the choice of the contractor, the contractor mobilises to carry out the field operations. Fieldwork, which the general public commonly identifies as "construction," can be regarded as a separate phase. Since these activities are discrete from the installation work, we isolate them into a distinct, final phase. The phases of a typical construction project are illustrated in Figure 1, which is a conceptual diagram. In addition, it displays, as a share of the overall budget, the number of funds the owner may commit by the end of each phase. The author

focused on the project operation phase where the contractor executes the construction works and its duration is considerably longer than other phases of the project life cycle.

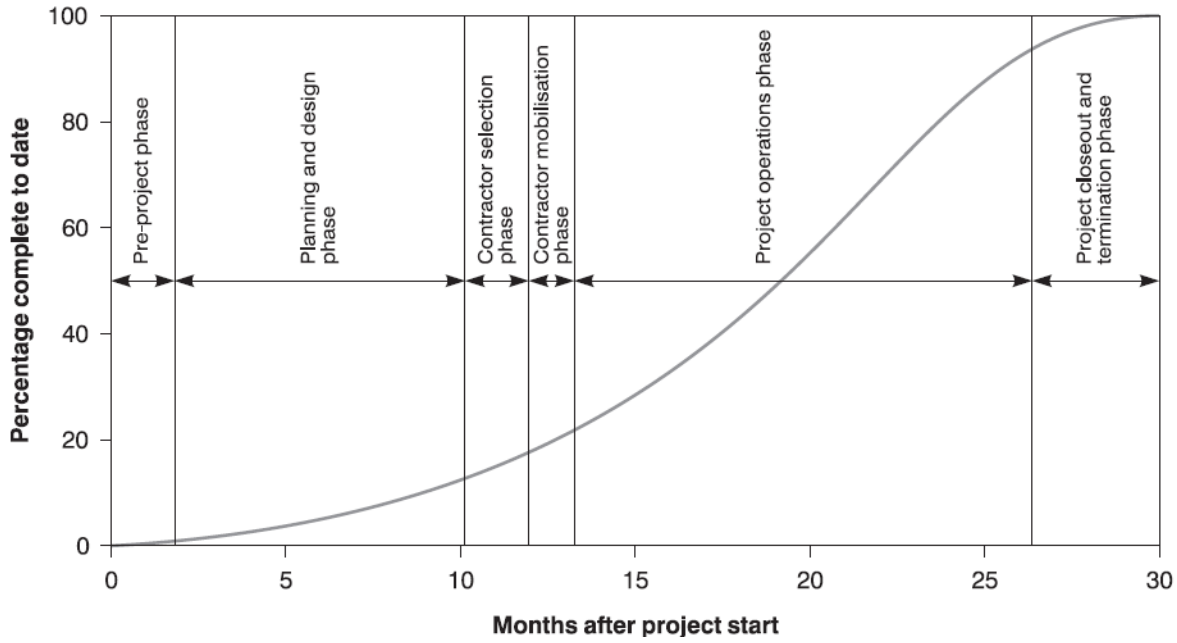

Figure 1 Phases of project life cycle(F. Lawrence Bennett, 2003)

The construction industry is significantly fluctuating, and shareholders are always at risk. Many construction failures occur each year, particularly among smaller, newer contractors. There are numerous statistics and metrics regarding the number of failed contractors each year. Perhaps focusing on a single year is too precise; however, approximately 70 percent of the contractors in the field on 1st of January of any given year will fail within seven years. Construction company owners and investors seek for a very high rate of return (ROR) on their investments due to the risky nature of the construction industry. If they could only make 1-2 percent on their initial out-of-pocket investment in the company, they would be better off placing their funds in a bank with government insurance and earning a fixed interest rate. To receive an acceptable ROR, contractors must comprehend and manage their accounting and financial responsibilities and risks (Holm, 2018). Since the cash flow of any construction project is the core element that sustains the success and continuity of any project, this paper discussed the main risks jeopardizing the cash flow and the mitigation plans for these risks to avoid prolonged negative cash flow.

1.2 Research problem, Objective, and Questions

After the first four years of operation, only about half of the new companies are still in business. Despite the fact that this is not usually attributable to cash flow problems, it is a significant concern. Glowacki (2015) demonstrated unequivocally that the company's position on the market was called into doubt when a cash flow issue was observed. Cash flow issues can be attributed to many failure causes. The inability to persuade creditors and potential lenders that this inadequacy is temporary and will not result in insolvency is a potential source of problems. In order to prepare for future adversity, it is crucial to anticipate cash requirements. Poor financial management, particularly inattention to cash flow management, is the primary reason the construction industry has the highest number of bankruptcies of any industry in the economy (Glowacki, 2015).

Cash flow is the essence of a project, particularly when the project is nearing completion or in the middle of the execution phase. On the basis of cash flow projections, top-level managers make managerial decisions. According to project life cycle analysis, inaccurate cash flow forecasts and deficient cash management lead to financial distress and negative cash flows (Sharifi & Bagherpour, 2016).

Negative cash flow has a direct correlation with project activity scheduling, and prolonged negative cash flow periods play an essential role in project sustainability, leading to project suspension or failure (Al-Joburi et al., 2012).

A negative cash flow happens when the cash out of the project exceeds the amount the cash in. In other words, it occurs when the project's expenditures exceed its income. When a company has negative cash flow, it must have enough liquidity to get through the negative cash flow periods(Glowacki, 2015).

Accordingly, the problem that needed to be researched was the prolonged and unexpected negative cash flow that happened during the construction phase of the project. This places the continuation of the project in jeopardy and has the potential to result in the failure of the project.

The purpose of the research was to investigate ways to mitigate the impact of the negative cash flow on a company's cash flow by providing funding in accordance with the procedures most frequently utilised in the industry. In addition to understanding

the various risk mitigation methods, the purpose of this research is to evaluate the effectiveness of these approaches by determining how they affected the negative cash flow and how effectively they reduced the adverse effects of each risk.

The author's goal was to accomplish this objective by providing answers to research questions that would assist the reader in comprehending the significance of the problem, the factors that contribute to the problem, and potential solutions to the problem. The following are the research questions that were asked:

- What are the causes of the negative cash flow?
- How often do the contractors face these events?
- How to predict a negative cash flow?
- How do impacts vary based on the phase of the project life cycle?
- How to mitigate or eliminate the risks of the negative cash flow?

1.3 Research Methodology

The research methodology employed in addressing the issue of optimizing construction cash flow to mitigate prolonged and unexpected negative cash flow was rigorous and thorough. It involved a comprehensive review of existing literature, an expert survey, qualitative data collection, and detailed case study analysis. The resulting findings and recommendations are well-supported and grounded in sound academic research.

The research began with a thorough review of the existing literature on cash flow management techniques, construction project risks, and their mitigation. Numerous scholarly journals, books, industry reports, and trustworthy online sources were consulted to comprehend the topic comprehensively. The literature review assisted in identifying the fundamental concepts, theories, and practises associated with cash flow optimisation and risk mitigation in the construction industry.

A survey was devised after conducting a literature review to collect expert opinions and validate the findings. The main objective of the survey was to identify the most significant construction cash flow risks based on their likelihood and impact besides the mitigation methods followed by the experts to mitigate prolonged and unexpected negative cash flow. The author utilised a mixed-methods for the research design

using quantitative and qualitative data collection techniques. The survey was disseminated to a sample of construction project management, finance, and risk management specialists. Efforts were made to gather various respondents from a variety of organisations and origins. Based on the survey results and qualitative data analysis, a case study was conducted to evaluate the efficacy of the identified risk mitigation strategies against the most prevalent risks.

The objective of the case study was to evaluate the efficacy of the identified risk mitigation strategies in enhancing cash flow and mitigating risks. Accordingly, the author utilized the case study by applying the prevalent risks concluded from the survey in order to comprehend the impact of these risks with reference to the cumulative negative net cash flow. Besides comprehending the impact of the risks, the author applied the mitigation methods concluded from the survey in order to identify the most efficient method against each risk.

It is essential to acknowledge the research methodology's limitations. The survey and case study relied on a specific sample of construction experts and projects, which may limit the applicability of the findings to other contexts. In addition, the research methodology was conducted within a limited timeframe and with limited resources, which may have impacted the exhaustiveness of the analysis.

Despite these limitations, the combined literature review approach, expert opinions gathered through survey and qualitative data collection, and case study analysis provide valuable insights into the cash flow management methods, risks, and mitigation strategies in construction projects.

The outcomes from the literature review, survey, and the case study will be presented and discussed in depth in the subsequent chapters.

2. Literature Review

The management of a company requires effective cash flow management strategies. Many researchers have attempted to develop optimal cash flow models and predict the cash flow of businesses and projects. Various studies have explored the use of time and cost integration technology to produce accurate cash flow findings with minimal human intervention using computer programs. However, most of these models did not account for the impact of unforeseeable issues on the project's cash flow due to uncertainties arising from the nature of the projects, such as unexpected costs, weather conditions, labor and material expenses, etc. In addition, a study on models integration of time, cost, accuracy of cash flows, and giving subcontractors the same amount of time contrary to the actual practice has been conducted. Typically, contractors adjust their payment method based on the performance and dependability of subcontractors, which may involve the use of mathematically/statistically derived cash flow models during the bidding phase. Nevertheless, these models are unreliable for estimating and defining the financial requirements of projects. Therefore, any cash flow management should begin with the development of a clear cash flow plan to determine the incoming cash flow of the company, cover the needs of cash outflows, estimate the adequacy of the cash available to control the project and advance the implementation process, avoid financing gaps whenever possible, and to a reasonable degree (Allethi et al., 2021). Accordingly, the author discussed the cash flow management process during the construction phase in details in order to identify the risks associated with the cash flow management method besides the attributable party to such risks. Afterwards the author clarified the consequences of the identified risks and their impact on the cash flow from the contractor’s perspective and how they enhance the negative cash flow causing additional financial burden on the contractor. Eventually the author discussed the mitigation process adopted by the contractor in order to overcome the impact of these risks by mitigating the impact of the unexpected negative cash flow.

2.1 Cash flow Management

Cash generated by a project is equal to cash receipts against cash expenditures. Suppose the cash expenditures for a project are less than the cash receipts. In that case, the project will generate cash that can be used for other projects, to cover general overhead, or to generate a profit for the project owners. If the cash receipt exceeds expenditures, the cash flow will be positive. On the other hand, if cash expenditures exceed cash receipts on a project, the company will need to provide cash to sustain the project, resulting in negative cash flow (Peterson, 2013).

When a construction company receives monthly progress payments for a project, three things distinguish the cash flow. First, the cash receipts only come in once a month, meaning there is a significant decrease in the cash the company has invested in the project when it receives payment from the employer. Second, the construction company can often delay payment of some construction costs paid to the subcontractors or suppliers until it receives payment from the owner, which means that a large portion of the owner's payment immediately goes to suppliers and subcontractors. Third, the owner holds onto some of the payments owed to the construction company until the project is completed, and this portion is called retention (Peterson, 2013).

Cui et al (2010) stated that the model for project cash flow management consists of the modules described below.

“Cash balance module”

The module that deals with the cash balance is an integral part of the project's construction phase, as it incorporates the cash flow from managing and financing activities. This module serves as the framework for the entire model, connecting all other modules. As shown in Figure 2, the module outlines the process of how the amount becomes an account receivable debit balance once the contractor delivers an invoice to the owner. After the owner examines the invoice, the payment is made several weeks later. This process ensures proper accounting and financial management of the project.

Cash collection generates a cash inflow for the contractor, which effectively increases the cash balance. During the project, a certain percentage of each

payment will be withheld as a retained amount until fifty percent of the work is completed. Once this threshold is met, no additional retainage will be held, but the accumulated quantity will be retained in the retainage receivable account until the project is completed and approved. Interest on savings accounts can also serve as an additional source of funds, and the contractor may choose to place the funds in an interest-bearing savings or checking account. Conversely, cash disbursements from operating activities represent the cash outflow from the initiative. The most crucial cash disbursement activities in a construction endeavour include material disbursements, payroll, payments to subcontractors, and sometimes equipment payments. These activities can be represented by the following equations.

$$CB_t = \sum_{k=0}^{t} (CR_k + RR_k + IS_k - CD_k) \qquad (1)$$

$$CR_t = BTO_{t-d} - RR_{t-d} \qquad (2)$$

Figure 2 Equations for the activities (Cui et al., 2010)

CB_t represents the cash balance for a specific period of time, CR_k should be the cash receipt at the same time k, RR_t is the retained reimbursement at specific time k, IS_k is the revenue obtained from the interest of the saving accounts, and CD_k is the payment that shall be obtained from other modules, $BTO_{t\text{-}d}$ is the invoice issued to the owner for specific duration and the d is the dime delay.

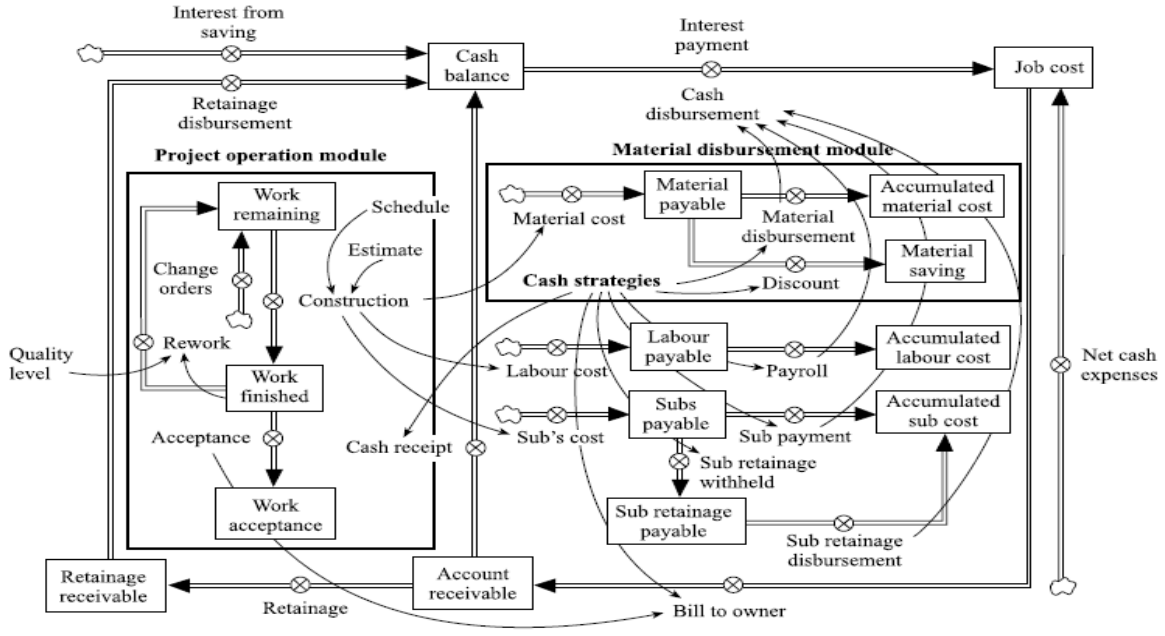

Figure 3 model for cash flow management(Cui et al., 2010)

“Material disbursement module”

The module for disbursing materials outlines cash transactions related to invoices, payments, discounts, and cost overruns. It is depicted in Figure 2 and models material costs and payment schedules separately. The material payable accrual account shows the difference between the cost of materials and their payment. The material invoice is based on the cost of the materials determined during the construction process. Typically, the contractor orders materials in advance and requires the supplier to adhere to the agreed delivery schedule. Once the contractor receives and approves the materials, the supplier sends a bill. To ensure material availability when needed, contractors may retain materials on-site for several days or weeks. This approach necessitates the delivery of materials before they are urgently required. As more contractors adopt lean principles and just-in-time material management, the inventory holding period has decreased. The cash flow model for the project will include various material management systems by advancing the material cost schedule. If the material cost schedule is frontloaded by one week, the material delivery schedule is one week ahead of the actual material cost schedule. Therefore, the contractor would keep a week's valuation of construction materials on-site.

To ensure timely payment, material invoices must be settled within the grace period specified in the material purchase agreement. Suppliers often offer discounts to encourage contractors to pay early for in-stock materials. In the construction industry, a standard discount term is '2/15, n/30', which means that payment is due in full within 30 days, but a 2% discount is available if the invoice is paid within 15 days. Contractors have the option to accept or decline the discount. If they choose to take advantage of the discount, they will need to pay for the materials earlier, which could result in increased overdraft balance and additional debt. This practice is typically factored into the material disbursement module, which also evaluates material payment policies by modifying the payment schedule (Cui et al., 2010). It is crucial to manage this process effectively to avoid exceeding credit limits, incurring additional interest expenses, and limiting future project financing.

“Project operation module”

When it comes to construction projects, there are many factors that can impact the flow of cash. Two major issues that can affect project dynamics, according to Kim (1988) and Cooper (1993), are rework and undiscovered errors. While rework is common in almost every construction project, the extent of it can vary. Cooper (1993) estimated that discovering errors can take anywhere from 25 to 75% of the time required to design the original work, which then requires a revision process. The project operation module focuses on the flow of work from incomplete to complete, with a revision cycle in between. Completed work is inspected and accepted before billing the owner, similar to a quality assurance workflow model. Change orders may also be necessary due to unforeseen site conditions or changes in owner requirements, leading to modifications in the scope of work. Rework and scope change expenses are represented as distinct flow variables in other modules, such as the material disbursement module, which includes cost overruns for increased material costs due to rework.

Other modules

The project's cash flow model encompasses various cash activities, including labor payments, equipment charges, subcontractor billings and disbursements, and subcontractor invoicing. This comprehensive approach ensures that all financial aspects of the project are accounted for and managed effectively. By implementing a thorough cash flow model, project managers can make informed decisions and mitigate potential financial risks, ultimately contributing to the project's success.

The labour payment module and subcontractor payment module are crucial components of the overall project management system. The former calculates labour costs based on various factors, including the payroll schedule and labour cost estimate. On the other hand, the latter follows a similar structure, with the prime contractor retaining a portion of the subcontractor's completed task. These modules are essential for ensuring that all financial outlays are accounted for and that the project is completed within budget and on time.

The retainage amount becomes a stock, named subcontractor retainage payable. After project completion and acceptance, the retainage is ultimately paid. A

comprehensive inventory of the module's equations is available upon request (Cui et al., 2010).

The effective management of project cash flow is crucial for project success. A system dynamics model can be employed to facilitate flexible cash flow management strategies, including payment and disbursement, cash planning and budgeting, and optimised cash balance. To maximise project cash flow, the implementation of project cash flow management strategies is necessary, which can be analysed through front-end loading, back-end loading, and optimal cash balance strategies (Cui et al., 2010).

“Front-end loading”

Front-end loading is a term used in the construction industry to describe payment techniques that focus on collecting receipts in the early stages of a project's operation. Some common front-end loading techniques include mobilisation costs, unbalanced pricing, and overbilling. These techniques are intended to ensure that a project receives sufficient funding at the outset to cover its initial expenses and set it on a sustainable path towards completion. By concentrating payments in the early stages of a project, front-end loading can help to ensure that construction projects are completed on time and within budget.

Before commencing construction, it is important to take into account the mobilisation costs associated with relocating personnel and equipment and setting up site facilities. These costs can be substantial, and in some cases, they can exceed 10% of the total contract value. To ensure timely payment, it is crucial to accurately invoice mobilisation expenses, which can significantly improve the project's cash flow and balance. By carefully considering these costs, project managers can minimise financial risks and ensure that construction proceeds smoothly.

One issue that can arise in project pricing is imbalanced pricing, which can take the form of overpricing early-stage work items and under-pricing later-stage work items. This can result in a disproportional allocation of project costs, known as a mathematically unbalanced offer, or a materially unbalanced bid. The latter can lead to additional costs for the owner due to changes in the bill of quantities. While mathematically unbalanced bids may be permitted in certain circumstances, it is

important to ensure that the lack of balance does not pose an intolerable risk to the owner.

One of the ways contractors can improve their cash flow is by invoicing for uninstalled materials. Many owners allow this method of front-end loading. According to EJCDC C-700 Article 14.02 and AIA standard contract documents A201 9.3.2, the value of materials stored on site can be added to the application for payment, provided that they are stored appropriately and are not at risk of being lost due to theft or deterioration. With the owner's approval, the value of materials and equipment stored off-site or in a supplier's warehouse may also be included on the invoice for payment. However, it's important to note that underbilling should never be used to compensate for overbilling in any situation. When the contractor overbills the proprietor at an early stage of construction, he must underbill later to make up for the overcharges (Cui et al., 2010).

“Back-end loading strategies”

The utilization of trade credit and subcontracting as back-end loading strategies is a common practice in construction projects. This involves the contractor receiving materials from a supplier but deferring payment until a later date, providing a source of working capital for the construction company. Suppliers play a significant role in the construction process, providing materials and support for projects. For example, a contractor may receive materials at the beginning of the month but defer payment for up to eight weeks, utilizing trade credit to support short-term financing. This strategy has been found to be effective for many construction companies (Cui et al., 2010).

When considering the utilization of trade credit, it is important to recognize the potential risks involved. While it may provide certain advantages, contractors must be diligent in their planning and management to ensure that they do not lose the trust of their suppliers. To fully incorporate a trade credit strategy into the system dynamics model, the researchers constructed a model that included flexible material disbursement schedules, allowing for the simulation of various trade credit policies. This approach provides a sound academic foundation for further exploration and refinement of trade credit practices.

Subcontracting is a widely recognized form of commercial credit in the construction industry. It allows prime contractors to utilize the labor, materials, and equipment of subcontractors for their projects, with payment being made at a later date. This practice is a common way of managing costs and resources in the construction industry.

One common practice among prime contractors is to employ a 'pay-when-paid' clause, which allows them to hold off on disbursing funds until they receive payment from the project's owner. Moreover, prime contractors may also choose to withhold retainage for subcontractors' work as a means of delaying cash transmission until the project's completion. These subcontracting policies have been integrated into a system dynamics model, which offers the flexibility to perform what-if analyses and forecast the potential outcomes of different subcontracting arrangements (Cui et al., 2010).

“Optimal cash balance”

Cash is required for the majority of daily transactions. In addition to this transactional motive, a contractor must maintain additional cash reserves for unforeseen expenses or precautionary measures. There are numerous causes of cost overruns and urgent revenue requirements in construction. Nonetheless, the opportunity cost of retaining excessive currency may be high, mainly when interest rates are high. In order to manage finances effectively, the contractor needs to find the right balance between having enough cash to cover expenses and avoiding having too much leftover. It's important to keep in mind that the specific financial management strategies used will depend on the contract format and project negotiations, and may not always be feasible (Cui et al., 2010).

Cash-in refers to the payments received by the contractor for completed works in construction projects. While obtaining a loan is one option for acquiring cash, monthly payments, retention releases, and advance payments are more commonly used. The details of all cash-in forms are explicitly outlined in contracts, in addition to loans. Cash-in flows can differ from the earned value of the project due to payment factors specified in contracts, resulting in a time gap between payment receipt and retention held (Giouvris, 2021). Click or tap here to enter text..

The provisions outlined in the contract specify various elements, including the methodology for measuring the completed tasks. In accordance with FIDIC (Conditions of Contract for Construction), the contractor is required to submit a monthly progress report to the independent engineer for approval (FIDIC, 2017). Following approval, the engineer will issue a payment certificate, which will be conveyed to the project's client/employer. Upon approval of the payment certificate, the employer will then proceed to compensate the contractor for the work that has been approved. Among the various options available for project payment, monthly progress payments are the most commonly utilized format, as opposed to milestone-based payments (Giouvris, 2021). According to Kenley (2005), contractors typically prefer and find periodic installments to be a satisfactory form of payment, which also reduces their financial expenses.

Customarily, the project owner withholds a portion of each monthly pay request from the general contractor, and the general contractor then withholds the same amount from its subcontractors. This withheld amount is referred to as retention or retainage, another form of cash management. Retention ensures that the contractor focuses on completing the project, including closing out all physical and administrative tasks. Retention establishes a fund for completing the project if contractors refuse or are unable to do so. Retention also functions as an incentive for contractors to complete the project efficiently. Since the teams have worked together previously, a general contractor may be able to persuade the proprietor of a negotiated project that they do not need to retain as much money. (Holm, 2018)

Halpin and Senior (2009) provide a simplified approach to cash flow management, as shown in Figure 3. This figure depicts curves for the overall project value and project costs to date. Typically, the project's execution starts at a moderate pace, gradually increases to a steady rate during the majority of its construction, and then slows down in its final phases. This approach provides a sound academic foundation for managing the cash flow of a project.

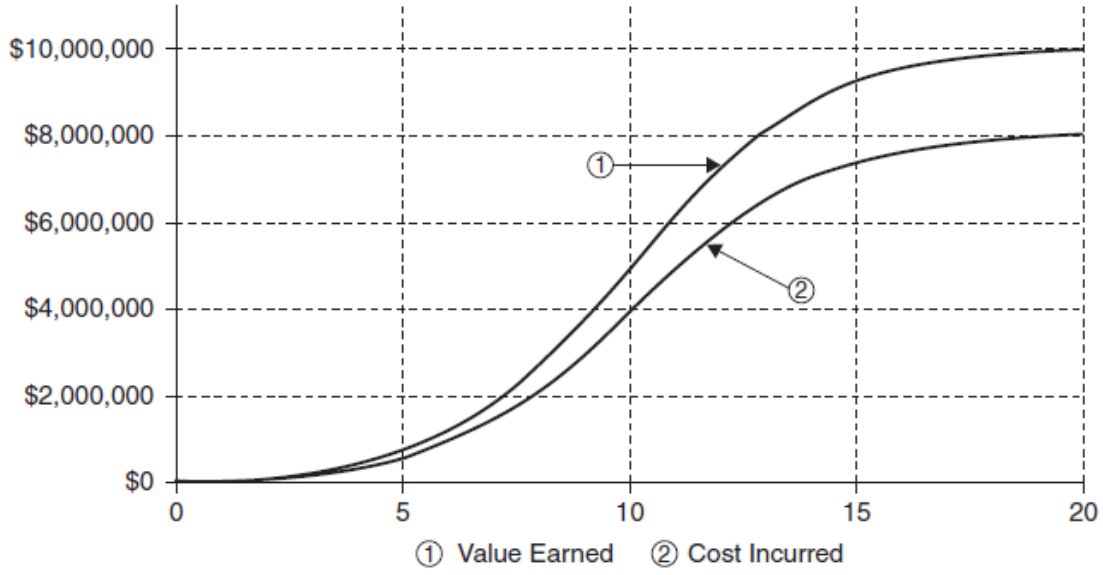

Figure 4 s curves for the earned value and incurred cost (Halpin & Senior, 2009)

The variations in execution rates can be observed in cumulative curves that resemble the letter "S." These graphs are commonly referred to as "S" curves, as noted by Halpin and Senior (2009). In most cases, the cumulative value curve exceeds the cost incurred curve, as the ideal scenario involves a project's value surpassing its total cost at any given time. However, because of payment delays, the disbursement flow can postpone the cumulative cost curve. This information provides a sound academic foundation for analyzing project management strategies.

In Figure 4, we can observe the disbursement flow, as well as two additional curves that provide further insight. The graph depicting the receipts flow displays a stair-step pattern, which effectively communicates the total amount of money received up to this point. The cash position curve, also referred to as net cash flow, illustrates the variation between expenses and receipts. In cases where the liquidity position is negative, it is commonly referred to as an overdraft, as noted by Halpin and Senior (2009). Overall, these visual aids help to provide a clear and comprehensive understanding of the financial situation at hand.

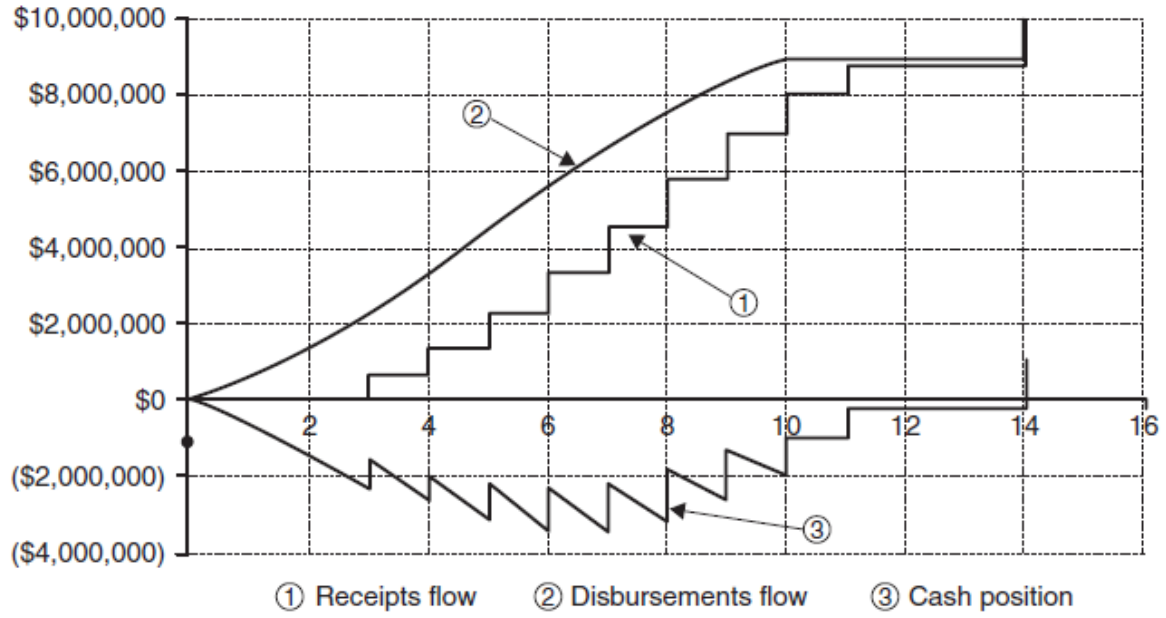

Figure 5 Receipts, disbursements, and cash position (Halpin & Senior, 2009)

The outflow of funds follows a curve that resembles an S shape, which can be simplified for ease of understanding. While the actual curve may appear more jagged due to fluctuations in currency outflows on a daily basis, the overall shape remains the same. This is commonly known as the expenditure flow curve.

The receipts flow illustrated in Figure 4 exhibits a distinct stair-step shape. The initial increase at the beginning of each month represents the monthly payment, which compensates for work completed weeks or even months ago. This delay in payment is a result of the invoicing payment cycle and is inherent in all contractual agreements. It is important to note that the first payment in Figure 4 occurs at the start of the third month, which is an acceptable delay for the approved payment certificate regarding work completed in the first month. The payment request is made at the start of the second month, and the remainder of that month is dedicated to preparing the request. This request is then evaluated by the owner's representative and sent to the client, who will require several days to prepare the payment check. (Halpin & Senior, 2009). This information is crucial for understanding the complex financial processes involved in construction projects and highlights the importance of timely and efficient payment cycles.

Figure 4 demonstrates the lower curve representing the project's net cash flow. The cash flow statement reflects the contractor's cash position during the project execution by indicating the variance between receipts and disbursements. The curve can be conceptualized as the project's "checking account" balance.

Due to payment delays and retention, this accounting account's balance remains negative for most of the project timeline until the cumulative progress payments are substantial enough to cover the expenses. Typically, this situation arises only when the owner releases the retention after the project. Contractors are expected to cover negative balances that arise from project expenditures, and they can acquire a line of credit from a bank to rectify this cash flow issue. This line of credit operates similarly to a personal credit card, as purchases are made using the available balance and interest is charged on any negative balance that remains outstanding (Halpin & Senior, 2009).

Halpin and Senior (2009) provided an example of four activities, as depicted in Figure 5. The project's initial cost was $200,000, but the contractor had included a profit of $10,000 (or 5%) in the proposal, bringing the total to $210,000. The proprietor retains 10% of all valid progress payment claims until one-half of the contract value has been constructed, approved, and acknowledged as complete. Once this threshold is met (i.e., $105,000 or 0.1%), the proprietor will transfer the invoiced amount, minus any retainage, to the contractor's account within 30 days of invoicing. The amount of each interim payment can be determined as follows: Payment =

1.05 x (Direct Cost + Indirect Cost) – 0.1 x 1.05 x (Direct Cost + Indirect Cost)

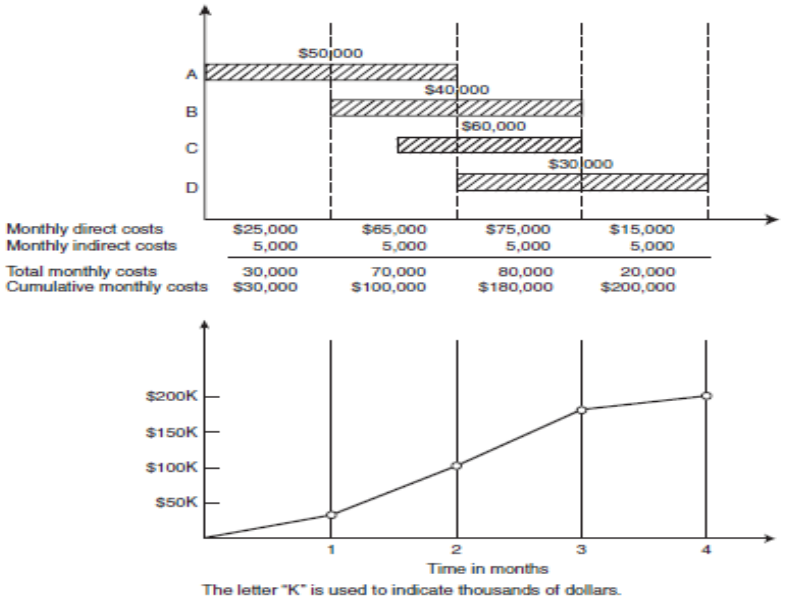

Figure 6 simple time-scaled budget (Halpin & Senior, 2009)

Upon reaching the halfway point of the contract, the negative aspect of retainage is removed from the calculation. However, due to the owner's tardiness in paying billings and withholding retainage, the income profile must be aligned with the expense S-curve. Figure 6 illustrates this strategy.

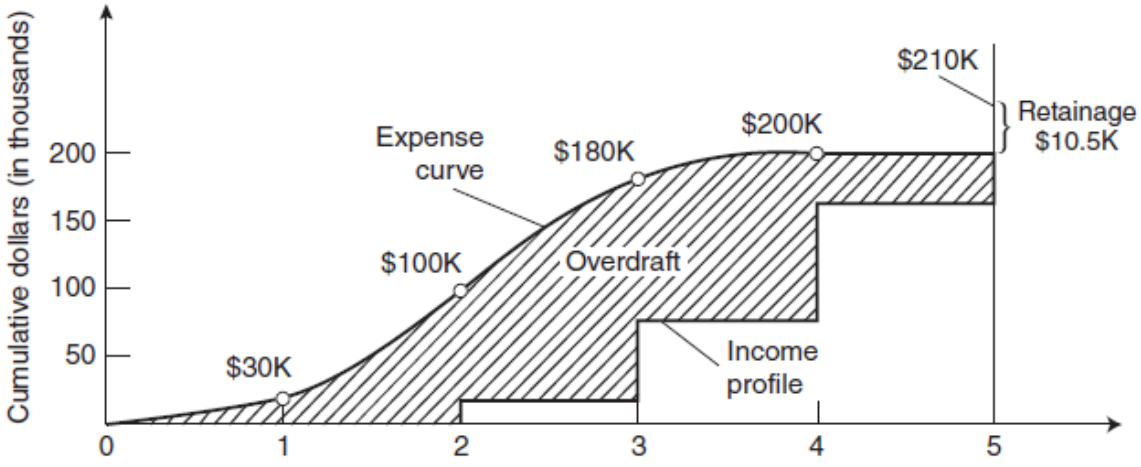

Figure 7 outflow and inflow profiles(Halpin & Senior, 2009)

As demonstrated by the preceding graphs and examples, the contractor is responsible for funding the project expenditures until its completion. Consequently, the project's net cash flow will always be negative, creating a financial burden on the contractor during the construction phase. Since the contractor views negative cash

flow as a financial burden that must be managed, the contractor must view it as a risk that must be mitigated in various ways, as indicated in the following sections.

2.2 Cash flow problems and risks

A risk refers to the possibility of complications and issues arising during a project's completion, as well as the occurrence of unforeseen circumstances that could affect at least one project objective (such as scope, schedule, cost, or quality), with an incidence rate greater than 0% but less than 100%. Furthermore, these future events must have unplanned or unanticipated consequences. While risks are a natural part of any project, they can be managed effectively to minimize their negative impact on project goals. The source of risk consists of inherent uncertainties and problems related to the fluctuating profit margin of the company, the competitive tendering process, the weather, the productivity of the job site, the political climate, inflation, contractual rights, market competition, etc. Construction companies are required to confront uncertain risks by carefully assessing their impact on project goals. To achieve this, a quantitative risk method can be employed to identify the riskiest projects, plan for potential sources of risk in each project, and manage each source during construction. It is important to distinguish between risk and uncertainty; while the former can be quantified, the latter is an unquantifiable risk (Erik & Rezakhani, 2012).

Mahmoud et al. (2021) highlighted the importance of precise cash flow projections in the construction industry to anticipate potential risks and integrate reserves to mitigate their impact on the cost performance of a project. In addition, contractor competency plays a significant role in predicting risks, and contractors should utilize their expertise to mitigate them. By taking these preventative measures, construction companies can reduce the risks associated with cost overruns and ensure successful project completion.

When considering the financial risks involved in a construction project, it is common for a cash flow forecast to be created at the beginning of the project. This is typically done using a net cash flow, value flow, and cost flow methodology. However, due to the unpredictable nature of the construction industry, these forecasts are subject to variations and deviations. Various factors can contribute to these risks, including

payment patterns, subcontractors and suppliers, and government regulations. There are two main perspectives when it comes to construction cash flow: the first defines cash flow as net receivables minus net payables during a project, while the second defines it as the actual inflow and outflow of funds. Many techniques have been developed to model cash flow based on historical data, and with advancements in technology, computer simulations and forecasts have become increasingly popular (Mahmoud et al., 2021).

Accordingly, Mahmoud et al. (2021) developed four tables based on the party that risk is attributed to, summarising all risk factors and their definitions that jeopardize the project cash flow and the completion of the project.

Table 1 Client-attributable risk factors associated with cash flow projections(Mahmoud et al., 2021)

Risk Factor	Definition
“Design Changes and Variation"	This refers to the modifications made to the basic design that result in variances and additional labor.
“Undocumented change orders”	This refers to a situation in which contractors are apprehensive about receiving paid for an unofficially issued work change.
“Underestimating project”	This occurs while calculating the likelihood of prospective risks and errors.
“Payment delay”	Explains a situation where the client delays the release of a certified payment
“Delay in releasing the retention”	Represents a circumstance where retention of completed work is not transferred to the contractor on schedule.
“Client’s insolvency”	Discusses the danger of customer insolvency and the prospect of total project suspension.
“Choosing the wrong consultants”	Awarding the design to unqualified designers
“Legal Conflicts”	Disputes arising between contracting parties during the building period.
“Unplanned bidding process”	Bidding procedure that is rushed and lacks fairness and professionalism
“Shortage of funds”	Describes a situation in which the client has insufficient

	finances to pay the contractor.
“Project schedule-driven”	The unreasonable schedule established by the client.
“Client’s improper Intervention”	Describes the client's participation in the construction stage and processes.
“Delays in response”	Discusses the client's delay in acquiring site access and right-of-way, as well as submitting orders and drawings
“Miscommunication”	Rework is caused by misunderstandings between parties.

Table 2 Consultant-attributable risk factors associated with cash flow projections (Mahmoud et al., 2021)

Risk Factor	Definition
“Delay in response”	Identifies the consultant's delay in acquiring site access and right-of-way, as well as in submitting orders and drawings.
“Consultant expertise”	Assigning unqualified designers
“Defective design (incorrect)”	Determines the cost of rework that must be performed due to design errors.
“Not coordinated design”	Describes the errors that occur when services are not properly integrated into the design.
“Ambiguous planning due to project complexity”	This occurs during the estimation of potential errors and dangers.
“Errors and omissions in the estimation and scope of works”	Inconsistency between the bill of materials, the drawings, and the specifications.
“Frequent changes of design by designers”	Determines the cost of redesigns necessitated by errors in the original design.

Table 3 Contractor-attributable risk factors associated with cash flow projections(Mahmoud et al., 2021)

Risk Factor	Definition
“Improper resource planning”	Increased labor costs; inefficient use of labor, materials, and machinery
“Inefficient overhead planning”	escalation of contractors' administrative and overhead costs

“Neglected reserve fund strategy”	Funds reserved for the warranty and performance guarantee
“Delay in progress”	Any delay in the construction activities
“Improper planning”	The excessive use of floats in the baseline schedule
“Failing to manage subcontractors”	Poor performance of the subcontractors leading delays
“Procurement delay”	Any delay in procuring the materials or low productivity rate of labour and equipment.
“Accidents (safety)”	Difficulty in obtaining reimbursement from insurance
“Inappropriate cash flow management”	Inadequate cash flow planning and management that results in insufficient funding and delays.
“Substandard Work Quality”	Additional or rework because of the poor quality
“Poor performance”	Describes the rework that occurs due to the inexperience and lack of understanding in construction processes of the contractors.
“Poor liaison with the local authority”	Describes the rework that occurs owing to contractors' lack of expertise and understanding of government requirements.
“Subcontractor’s insolvency”	Describes the possibility of subcontractor bankruptcy
“Contractor insolvency”	Describes the likelihood of contractor bankruptcy.
“Legal conflicts”	Accepting interim assessments on-site.

Table 4 External parties-attributable risk factors associated with cash flow projections (Mahmoud et al., 2021)

Risk Factor	Definition
“Force Majeure”	Acts of God (earthquake, landslide, wind, rain, and flood), war, and political instability are all causes of damage.
“Inflation rate increase”	Prices fluctuating rapidly and the expense of life increasing.
“Exchange rate fluctuation”	Variations of the currency exchange rate
“Changes in interest rates”	Changes in interest rates for cash and bank facilities can occur suddenly.
“Changes in legislation”	Describes the amendments to the building codes' and government's laws and regulations.

“Culture difference”	Cultural differences between parties and local protectionism generate conflicts.
“Unforeseen site conditions”	Describes the unusual subsurface and surface site conditions.
“Labour dispute and strike”	Assesses the impact of labor and management disputes on the completion of the project.

Mahmoud et al. (2021) created the tables, as mentioned earlier, to standardize the definitions of the risks affecting the construction industries and to eliminate any misunderstandings resulting from the diverse backgrounds of the parties.

A crucial factor to consider when relying on a cash flow forecast is to have a thorough understanding of how it was created and the limitations of the data that informed it. It is also essential to adapt the assumptions as circumstances change, such as modifications in the design specification, inflation, interest and exchange rates, the complexity of the building, estimation error, and sequence adjustments to mitigate delays. By taking these factors into account, one can develop a robust and reliable cash flow forecast that can guide decision-making and lead to successful outcomes (Royal Institution of Chartered Surveyors., 2011).

Failure to convince creditors and lenders that cash flow issues are temporary and won't lead to insolvency can cause problems. It's important to anticipate cash requirements to prepare for future challenges. Financial, supplier, subcontractor, and communication issues can all contribute to project failure. Cash flow falls under the communication category and delays can harm the project and the entity's reputation over time (Glowacki, 2015).

When a contractor experiences inadequate cash flow, they may struggle to fulfill agreed payment terms, leading to a shortage of labor and materials, decreased performance, and a weakened position. If this issue is not addressed promptly, it could worsen, causing the contractor's employer to be dissatisfied with the project's subpar results. This could result in financial institutions collapsing, subcontractors and suppliers becoming distressed, and ultimately lead to insolvency (Giouvris, 2021).

Contractors often request loans due to insufficient planning. Although the client pays the agreed-upon amount for completed work, the contractor may face cash flow

issues if expenses exceed the retained percentage or other contract terms. However, borrowing money may not always solve negative cash flow problems. It's important for contractors to carefully plan their expenses, consider future profits, and borrow money wisely to ensure the longevity of their company (Giouvris, 2021).

In the course of the project, the owner is required to make regular payments to the contractor. However, the contractor may face financial challenges as the project advances, particularly if they lack the necessary resources to handle the negative cash flow. This may result in delays in progress payments from the owner, which could ultimately impact the project's completion. This situation is caused by project expenditures exceeding cumulative progress payments made by the owner to the contractor (Shash & Qarra, 2018).

Poor cost performance of construction projects is the norm rather than the exception, and cost overruns result in significant financial losses for both customers and contractors. It is indicated that global risk factors present more tremendous hindrances for construction contractors, who need to become more acquainted with them. In addition, they need more techniques and instruments to manage these risks effectively (Baloi & Price, 2003).

2.3 Negative Cash flow & its consequences

As per Oxley & Poskitt's (1996) theory, cash flow refers to the net cash received or disbursed during the same interest period. A positive cash flow indicates net receipts in a specific period or year, while a negative cash flow indicates net disbursements.

A negative cash flow occurs when the money coming out of the project is greater than the amount coming into the project. In other words, it occurs when the project's disbursements are higher than its income. When a company is experiencing negative cash flow, it must have sufficient liquidity to survive the negative cash flow periods (Glowacki, 2015).

The term "net cash flow" refers to the difference between cash revenues and payments made over a specific period. If the net cash flow is positive, the contractor can execute a self-financing project; however, if the net cash flow is negative, the contractor will need to obtain funds by borrowing money or using the company's

equity. It is essential to keep in mind that the most significant consideration in financial planning is the amount of time available (Giouvris, 2021).

The disbursement flow is seen in Figure 8, which also contains two added curves. A graphical representation of the received payments over time is illustrated through a plot resembling a staircase. This plot provides a cumulative view of the total amount of money received up to a specific point in time. The cash position curve, often called the net cash flow curve, illustrates the difference between cash receipts and cash payments. When there is a deficit in the cash situation, this is referred to as an overdraft (Halpin & Senior, 2009).

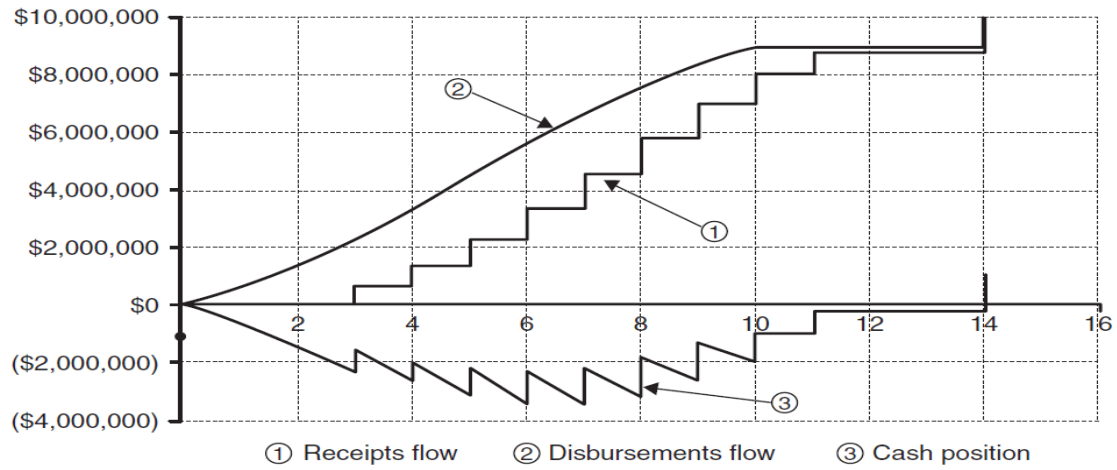

Figure 8 Receipt, Disbursement, and cash position (Halpin & Senior, 2009)

The graph illustrated in Figure 8 portrays the net cash flow of the project, which is represented by a sawtooth curve at the bottom. This curve effectively tracks the contractor's cash status throughout the project by monitoring the difference between receipts and disbursements. In essence, it displays the project's "checking account" balance. However, owing to the payment lag and retainage, this balance remains negative for the majority of the project's duration until the cumulative progress payments are sufficient to offset the expenses. This typically occurs when the owner finally releases the retainage after the project, and the contractor must make up for the deficit (Halpin & Senior, 2009).

The S-Curve is a crucial tool used by financial management departments to predict the cash flow of a project during its implementation phase. However, it is essential that the project accurately reflects the quantities owed from the beginning to ensure its accuracy. The S-Curve only shows the intended work on site and doesn't account

for changes in materials or work. Therefore, it may not be enough for the financial management department to meet the progress payment certificate deadline (Marzouq AL-NASSAFI, 2022).

It is a well-documented fact that delays in construction projects are a pervasive issue that has been the subject of extensive research by industry experts. These delays can often be traced back to financial factors, which are the main contributing factors. Specifically, late payments, inadequate cash flow management, insufficient funding, and fluctuations in the financial market have all been identified as the primary culprits responsible for such delays. Also, by governing the financial positions, the project cash flow (PCF) provides the contractor with a basis for making appropriate decisions for project continuation and success (positive or negative balance). Cash is provided by current assets (self-funding), loan funds, and down payments (Marzouq AL-NASSAFI, 2022).

When attempting to cover their expenses, contractors experience cash flow deficits. However, a considerable number of contractors are experiencing different issues. This would be detrimental if the company encountered a period of stagnation with no construction projects. Contractors are developing monthly cash reports to ensure adequate cash flow management throughout their projects, enabling them to keep track of their monthly expenses and profits. Contractors are too familiar with being pushed by subcontractors and suppliers when funds are owed; therefore, they must pay the respective parties efficiently to ensure robust and enduring collaboration. With efficient cash flow management practices, businesses can endure (Koopman & Cumberlege, 2021).

When cash flow is negative for an extended length of time, this creates significant challenges and frequently results in unfavourable outcomes that can vary from the delay of a project up to bankruptcy (Al-Joburi et al., 2012).

Al-Joburi et al. (2012) then analysed patterns of negative cash flow and the effects these patterns had on the execution of the project. They analysed data about scheduling and finances for roughly 40 different projects. According to the data analysis findings, each of the selected projects had a negative cash flow for between 30 and 70 percent of the projects.

Al-Joburi et al., (2012) conducted a study discussing negative cash flow and its impact on the Dubai construction industry. The study consisted of four case studies and the following are some of the findings:

- The actual expenses were consistently less than the budgeted expenses.
- The probability of project failure increases when the contractor schedules activities that cost more than the advance payment.
- There needed to be a standard format for bookkeeping and financial records. In other words, the government does not require contractors to provide financial and scheduling data in a specific format or to maintain specific financial information. Each of the four contractors utilized unique software and maintained vastly different levels of financial detail.
- Negative cash flow is directly related to the scheduling of project activities, and costly activities deplete cash flow. The typical payment cycle of 60 to 90 days (if no delays occur) directly and frequently affects cash flow.
- Extensive negative cash flow periods and quantities are crucial to the viability of a project and may result in its failure.
- All projects had negative cash flow for 30 to 70 percent of their duration.

In light of the preceding, the author concluded that a negative cash flow occurs when the contractor's expenses during a specific project duration period exceed the contractor's payments. Therefore, the contractor was required to fund project activities through self-funding, financing, down payments, or payments from other projects. Such financing methods are viewed as financial burdens on the contractor, as the contractor is forced to reduce available liquidity, pay interest to the bank, be in debt to the owner due to the down payment, or even put the cash flow of other projects at risk. Therefore, the contractor must mitigate the unanticipated negative cash flow to reduce the likelihood of further project delays or even bankruptcy.

2.4 Mitigation Methods

Because borrowing money should be done wisely based on plans that reflect the demands and foresee future gains for contractors, there is no solution to negative cash flows that can be accomplished through borrowing money. (Giouvris, 2021)

Akinbile et al.,(2018) suggested several recommendations are made to provide direction for development in the technical and construction fields and these recommendations are as followed:

- Technical risk, performing a meticulous site investigation before starting any construction project is an imperative step. Moreover, it is vital to draft the construction work specifications with exact language that is straightforward and uncluttered, avoiding convoluted phrasing. By doing so, we can guarantee that the specifications are extensive and straightforward.
- Construction risks, to ensure the success of a construction project, it is crucial to have an abundance of resources readily available on site, including materials, equipment, funds, and skilled labor. Additionally, the construction plans should be well-defined, and personnel should possess the necessary expertise to fully comprehend the scope of work involved. By adhering to these fundamental principles, we can achieve a prosperous and efficient outcome for our construction project.

Halpin & Senior (2009) introduced various cash flow optimisation strategies: by instituting an efficient collection system. Construction companies generally need more effective collection procedures. Contractors can decrease the area between the disbursement curve and receipts profile by reducing the time between work placement and cash payment by the client. It's important for contractors to be more attentive in enforcing overdue accounts receivable. On the other hand, credit card companies are highly vigilant in monitoring cardholders with delinquent accounts.

Vendors can be paid on time to make use of the discounts, and vendors provide trade credit as an incentive for prompt payment. On a vendor's invoice, for instance, there may be a 2/10 net 30 discount.

According to the agreement, a discount of 2% can be obtained if payment is made within ten days. Nevertheless, if the payment is not received within this period, the full amount must be paid by the 30^{th} day. Additionally, the contractor has the option to skip the 2% discount and pay the total amount on the 30^{th} day.

The compensation process within the construction industry has recently been a topic of discussion, particularly regarding the payment of subcontractors. One approach that has been adopted by contractors to ensure timely payment for their

subcontractors is to offer the option of paying them when an interim payment is received. However, a concerning trend has emerged wherein contractors are imposing "pay when paid" provisions on subcontractors. This arrangement defers payment until the contractor receives payment from the owner, which has the potential to cause payment delays for subcontractors. The implementation of such provisions is not without its challenges, as some subcontractors may opt not to work with contractors that enforce "pay when paid" policies. It is imperative that the construction industry establishes fair and just payment practices that prioritize timely compensation for all workers involved in the construction process.

A strategy called "unbalancing the bid" can be used to shift the owner payment flow trajectory to the left, but it is only applicable to unit price contracts. In such contracts, the proprietor agrees to a pre-determined schedule of unit prices for the work during the bidding process, which serves as the basis for payment of work orders.

During the early stages of a construction project, it is not uncommon for contractors to submit inflated unit prices for certain bid items. This strategy is often employed to accelerate reimbursement for the work during the construction period. However, this practice can result in front-end loading, as the costs of the bid items become unbalanced. In order to offset this price increase, contractors may quote prices for closeout items, such as landscaping and paving, that are below cost. This strategy effectively balances out the bid items and ensures that the project's budget remains manageable (Halpin & Senior, 2009).

The aforementioned strategies aimed to optimise the cash flow by reducing the gap between the disbursements curve and the payment curve as shown in figure 9. The reduction in the gap between the curves leads to reduction in the overdraft, and such reduction can be represented by either shifting the payments curve to the left or shifting the disbarments curve to the right and such change in the curve can be done by receiving the payments as soon as the work is delivered or by delaying the contractor’s payments towards supplier and subcontractors (Halpin & Senior, 2009).

The strategies previously discussed for optimizing cash flow are often utilized in combination rather than in isolation, and each has its own set of limitations. For example, obtaining external financing typically involves the payment of interest, which must be accounted for in the bidding process. Failure to accurately forecast

interest costs can result in insufficient coverage of these expenses, directly impacting the contractor's profitability.

Similarly, delaying payment to suppliers within the specified credit limits may result in the loss of early payment discounts. Adopting an aggressive approach to debt collection may negatively impact future business with the affected client. Therefore, it is essential to carefully evaluate the potential risks and benefits of each strategy before implementing them.

On the other hand, it is advisable for contractors to carefully choose the projects they bid on and work only with owners who have a track record of timely payments. Delays in paying subcontractors may lead to negative consequences, including the potential blacklisting of the prime contractor by more qualified subcontractors. Such actions can damage the contractor's reputation, particularly in the context of internal cost reduction initiatives that require significant organizational efforts that some contractors may prefer not to undertake (Halpin & Senior, 2009).

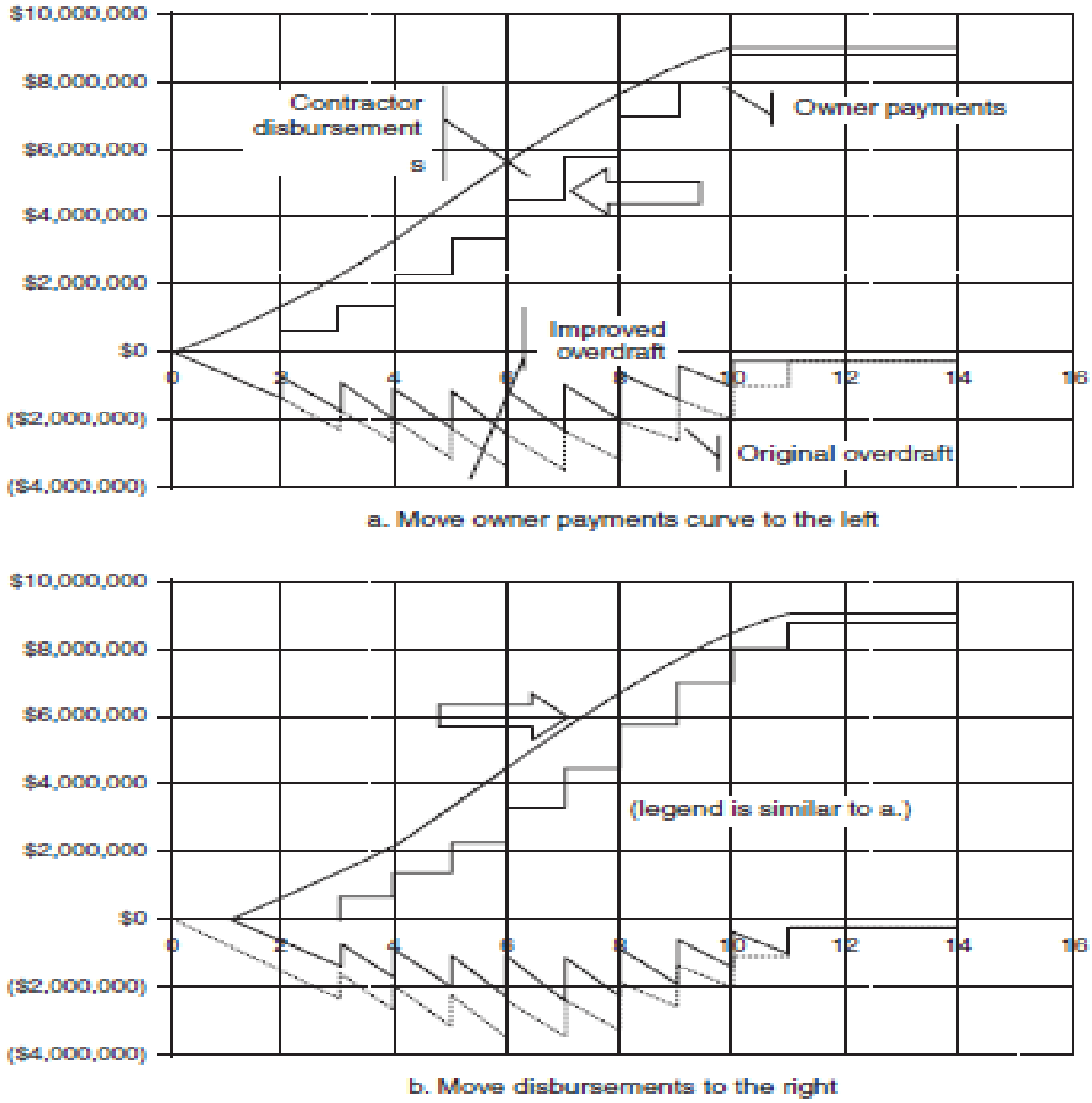

Figure 9 cash flow optimization (Halpin & Senior, 2009)

The author concluded that the literature review provided a comprehensive understanding of the current research on negative cash flow, cash flow management procedures, risks, and mitigation techniques. The examined studies reveal crucial observations and patterns that allow the author to identify the threats to the cash flow of the projects. Accordingly, the paper discussed further exploration through a survey to provide a better understanding of the correlation between these risks and the unexpected and prolonged cash flow in light of the severity and likelihood of the risks. In general, this review emphasises the significance of continued research in this field to enhance our knowledge and capacity to address the challenges contractors face.

3 Risk Identification

The survey strategy is generally associated with the deductive method, a common and prominent method in business and management studies.

As mentioned at the outset of this study, the methodology and approach utilised for this study are based on a literature review to comprehend the risks jeopardising the construction by causing prolonged and unexpected negative cash flow. The author conducted a survey to validate the previous chapter's literature review findings. The author designed the survey according to (Saunders et al., 2009). The author utilized a research design that combined quantitative and qualitative data collection methods.

Since the author lacked access to a substantial proportion of the population and there was a need to draw statistical conclusions from the samples, the author opted for non-probability purposive sampling as shown in figure 10.

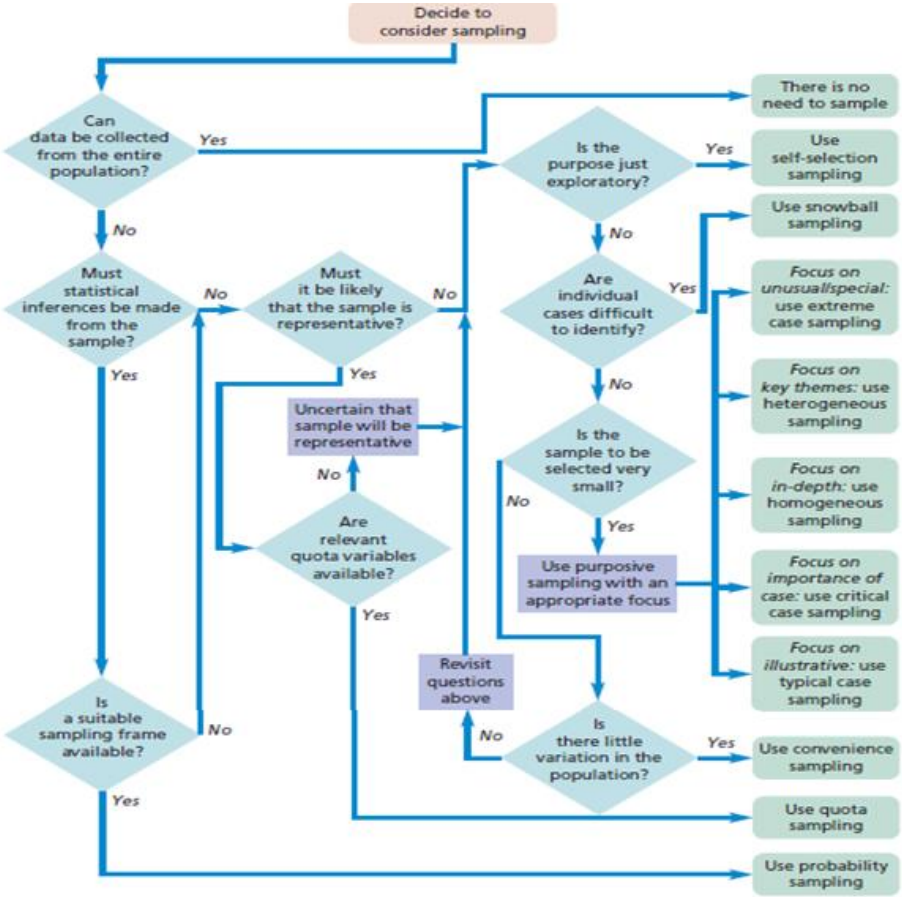

Figure 10 Selecting Process of the non-probability sampling method(Saunders et al., 2009)

In addition to the sampling technique, the author assessed the survey's validity using the content validity method. In this context, content validity refers to how well the questions in a questionnaire measure up to the research questions they are intended to address. Adequate coverage can be evaluated in various methods. One is by carefully defining the research through a literature review and, if necessary, prior consultation with others. Using a sample of expert individuals to determine whether each question in the questionnaire is "essential," "useful but not essential," or "not necessary" is another option (Saunders et al., 2009).

In light of the aforementioned the author developed a structure questionnaire with the help of one of the Google Services which is Google Sheets. The questionnaire was digitally distributed in order to reach construction experts from various countries in order to validate the risks concluded from the literature review and to classify these risks based on their likelihood and the severity of each risk.

3.1 Questionnaire Design

The survey was distributed through the author's LinkedIn account, the largest online professional network. Due to the fact that the sample was purposive, the respondents were introduced to the survey through a cover letter outlining the purpose of the survey and the target population.

According to Saunders et al. (2009), a portion of the sample would disregard the cover letter; therefore, the author was required to introduce the topic within the survey by stating the following: "*Thank you for taking the time to participate in this survey. The conducted survey aims to identify the main causes of the unexpected and the prolonged negative cash flow in the construction field. The survey aims to identify the risks jeopardising the completion of the construction project by prolonging the negative cash flow. Your participation is critical to help us understand the challenges faced by the industry and develop strategies to mitigate the impact of negative cash flow*".

Following the introduction, further classification took place where the author classified the respondents based on years of experience in the construction field, the type of experience they obtained within those years, academic background, and location. Such data were beneficial in identifying the depth of understanding of each

respondent and background. Based on these questions, the author could obtain fair judgement regarding the responses of the rest of the survey.

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After the classification and ensuring that the respondents had the required experience, knowledge and background, the author shall verify the respondents' familiarity with the main topic of the survey which is the unexpected negative cash flow. Accordingly, the author asked if the respondent faced the unexpected negative cash flow and if the unexpected negative cash flow is considered as a critical issue.

Since the respondents had the required knowledge, the author became able to ask them to choose the top three risks that contribute to the unexpected and prolonged negative cash flow. The risks shown in the survey were the most recurrent in the literature review, and the author gave the respondents the liberty to add any risks in order to ensure the inclusivity of the survey and enhance the validity of the survey by comparing the content with previous surveys mentioned in the literature review. The risks mentioned in the survey are delayed payment, change order, delayed procurement, change in the scope of work, inflation, change in the interest rate, underestimation during tender, change in a sequence of activities, site condition, and poor planning beside a blank slot for the respondents to fill with any risk that was not mentioned in the survey.

In addition to identifying the three most common risks contributing to unanticipated negative cash flow, respondents were required to assess the likelihood and severity of these risks in order to comprehend their impact on cash flow. By comparing the responses to the three most prevalent risks, the likelihood of the risk, and its severity, the author became able to prioritise and rate the risks based on likelihood and severity so that they can be applied to the case study.

The identification process was followed by open questions where the respondents were able to share the mitigation process for the unexpected negative cash flow and

the methods followed to optimize the cash flow. The purpose behind such questions was to understand the mitigation methods adopted by companies and their efficiency.

3.2 Results and Analysis

Since the author utilised a mixed-methods research design using quantitative and qualitative data collection techniques and in light of Saunders et al., (2009) recommendations, the author surveyed 33 experts as the required minimum sample size is 30 in order to enhance the accuracy of the results. A total 33 experts responded to the online survey posted on LinkedIn and the profile of the respondents was categorised based on years of experience, field of experience, education background and location.

According to the data illustrated in Figure 11, twenty of the thirty-two respondents had more than five years of experience working in the construction business. The fact that 88% of respondents were seasoned professionals makes this information more accurate and reliable, which raised the reliability of the responses.

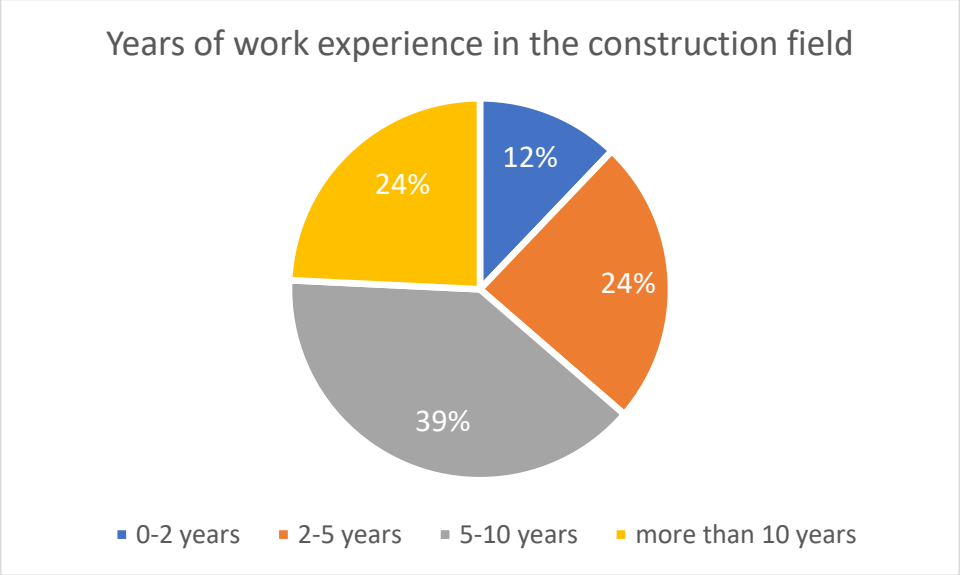

Figure 11 Level of Work Experience

As the respondents had the necessary experience in the construction industry, the author followed the previous question with a question about their involvement in the project. In light of each participant's job description, their respective roles affected their perspective on the impact and mitigation methods of the unexpected negative cash flow. The roles of the respondents depicted in Figure 12 were project

managers, project engineers, cost control, site engineers, planners, project coordinators, business developers, architects, owner engineers, and senior BDM executives. In order to facilitate the classification process, the author has divided these positions into three primary categories.

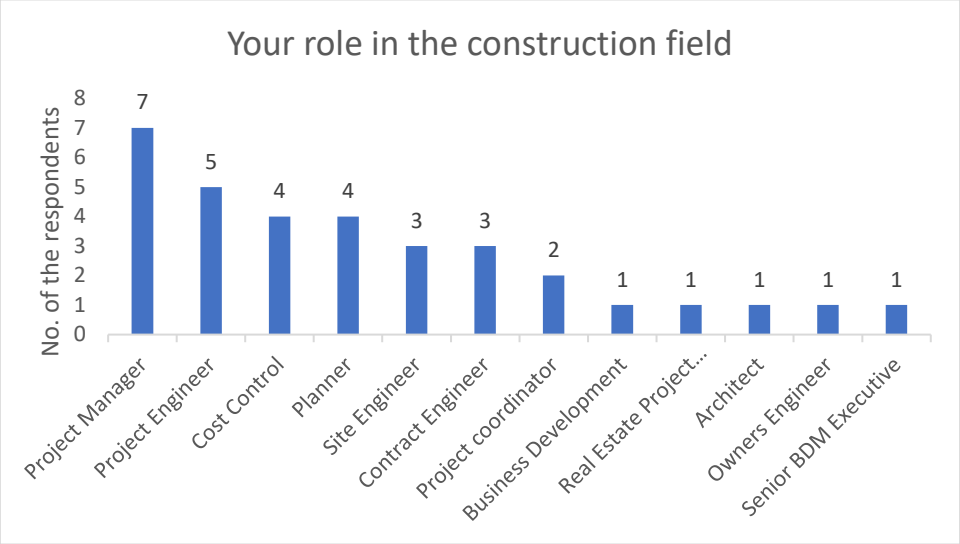

Figure 12 Role of the respondents

The categories were created based on the type of work and collaboration with (Chartered Institute of Building (Great Britain), 2011). These categories consisted of management, site, and engineering roles. The management roles included planning, cost control, business development, and BDM. The site roles included project engineer, site engineer, and project coordinator. The engineering roles included architect and owner's engineer. Out of these categories, most of the respondents (20) were employed in the management field, while 11 were employed in the site field. The respondents played a crucial role in controlling the cash flow as they were responsible for making budget and site activity decisions.

The author asked the survey respondents to share their academic background as it was necessary in making decisions. This was because work experience was just one of the many factors that influenced decisions related to cash flow optimization. Out of all the respondents, 58% had completed their bachelor's degree, and 39% had completed their master's degree, as shown in Fig.13. The academic and professional qualifications the respondents exhibited instilled confidence in their responses' reliability.

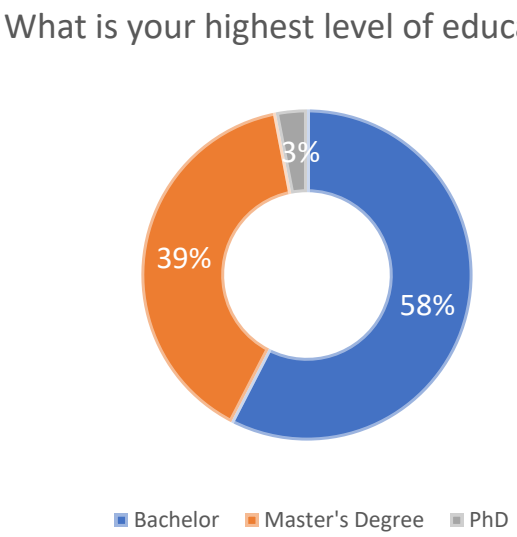

Figure 13 Academic background

The author chose not to specify a location or country for the study based on the literature review covering various global locations such as the United Kingdom, United Arab Emirates, Egypt, Greece, etc. In addition, the author decided to collect information about the locations of the companies where respondents had previously worked to determine if mitigation or optimisation methods varied based on the location of the respondents' former employers. However, most respondents laboured in Egypt, India, Saudi Arabia, the United Arab Emirates, Nigeria, Mexico, Germany, and other countries, as shown in Table 5. As some respondents worked in various countries, the total number of respondents exceeded 33.

Table 5 Countries where respondents worked

Response	No. of Respondents
Egypt	14
Saudi Arabia	3
Nigeria	4
India	5
Mexico	2
Germany	2
United Arab Emirates	4
United States	1
Finland	2
Canada	1
Netherland	1
Ghana	1
Pakistan	1

According to the findings in Fig.14, 87.5% of the survey participants experienced unexpected negative cash flow, indicating that they had personal experience with the issue. Even though 12.1% did not experience it, 100% of the respondents recognized the significance of unexpected negative cash flow and believed it should be addressed. This data highlighted the importance of the research and the necessity for a better understanding of industry risks that can result in unexpected negative cash flow.

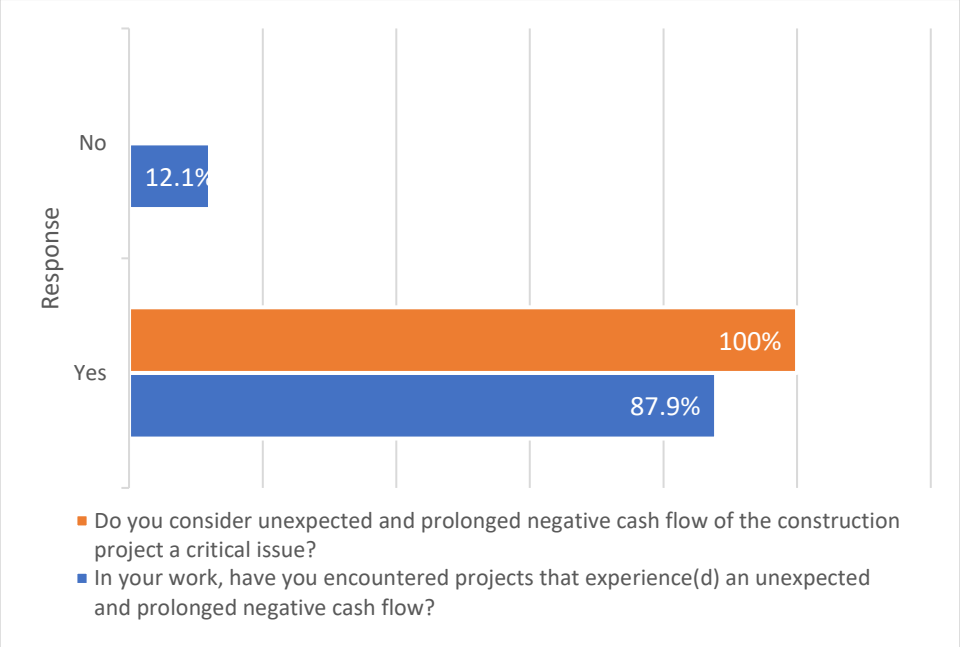

Figure 14 Familiarity of the respondents with the issue

The author asked respondents, with reference to the literature review, to address the three most prevalent risks contributing to unexpected and protracted negative cash flow. Respondents were free to select three risks from a list of ten prevalent risks addressed by the author based on a literature review. As depicted in Fig. 15, the top three risks contributing to unexpected and protracted negative cash flow were delayed payment, poor planning, and underestimation during the bidding process, with 67%, 52%, and 45% of respondents agreeing with each risk.

Identifying the three most prevalent risks could have been better in comprehending the significance of these risks; consequently, the question was followed by two others designed to elucidate the likelihood and impact of these risks. Comprehension of the likelihood and impact of the ten risks listed above would enhance the reader's

comprehension. If any risk had a greater likelihood and impact on cash flow, the author would be required to include it in the case study.

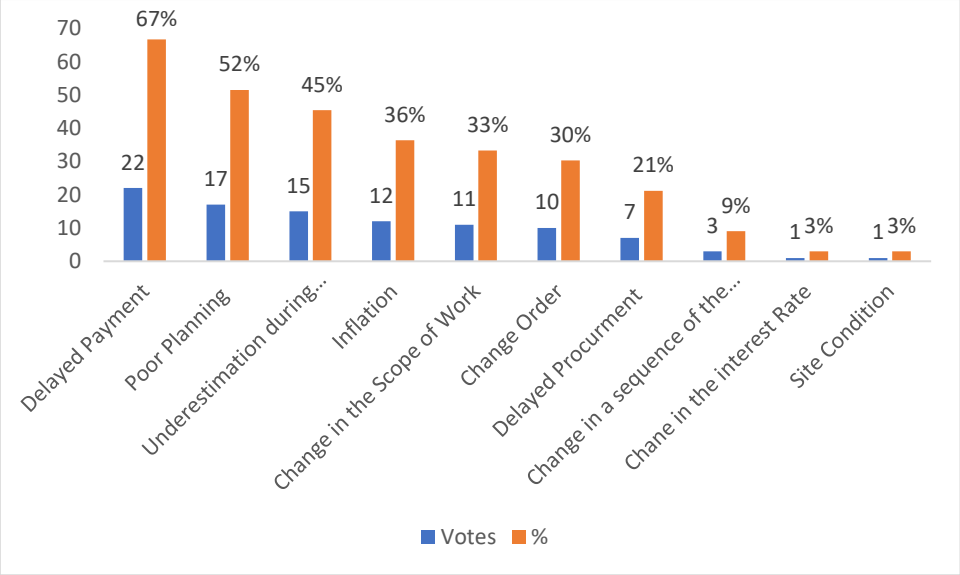

Figure 15 Three most common risk contributing to the unexpected and prolonged negative cash flow

As depicted in Fig.16, respondents concurred that delayed payment, poor planning, change orders, and tender underestimation were very likely to occur in projects. However, underestimation during tender and change order had the exact percentages for very likely and likely regarding the likelihood score, making them interchangeable; a further investigation was conducted by addressing the following question.

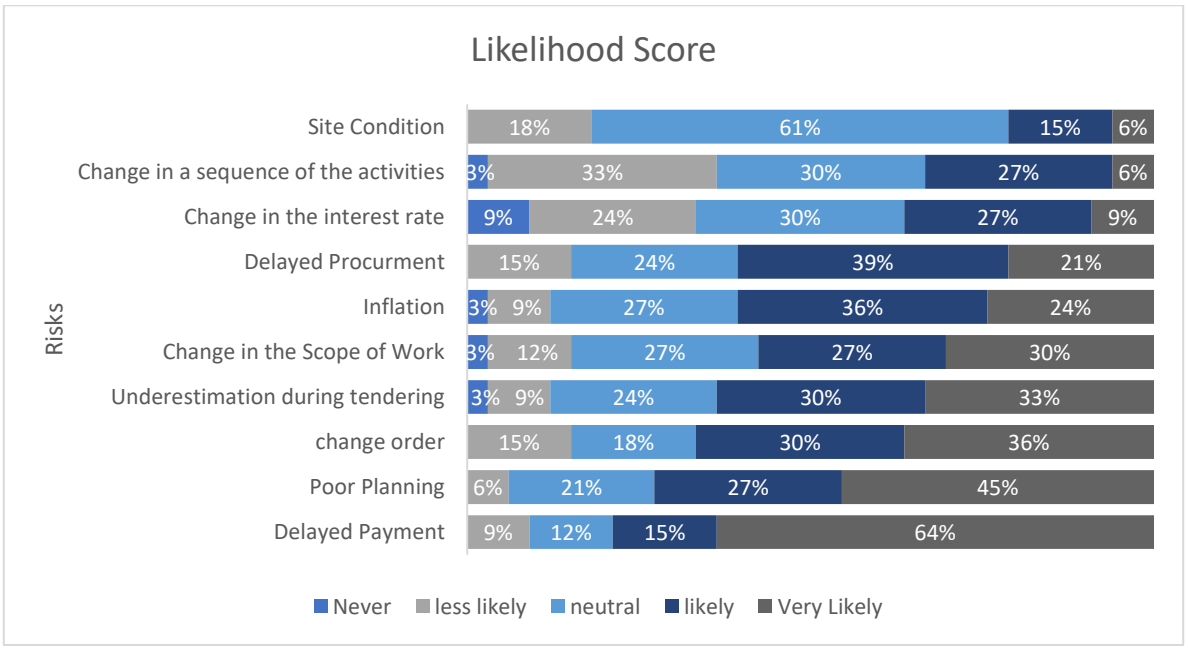

Figure 16 Likelihood score

The investigation focused on analysing how each event affected the cash flow. The impact of each event was categorized as extreme, high, moderate, or low. The categorization was based on the highest percentage among the four categories. It was found that tender underestimates, poor planning, and delayed payment had the most significant impact on the cash flow. Figure 17 provides a visual representation of this information.

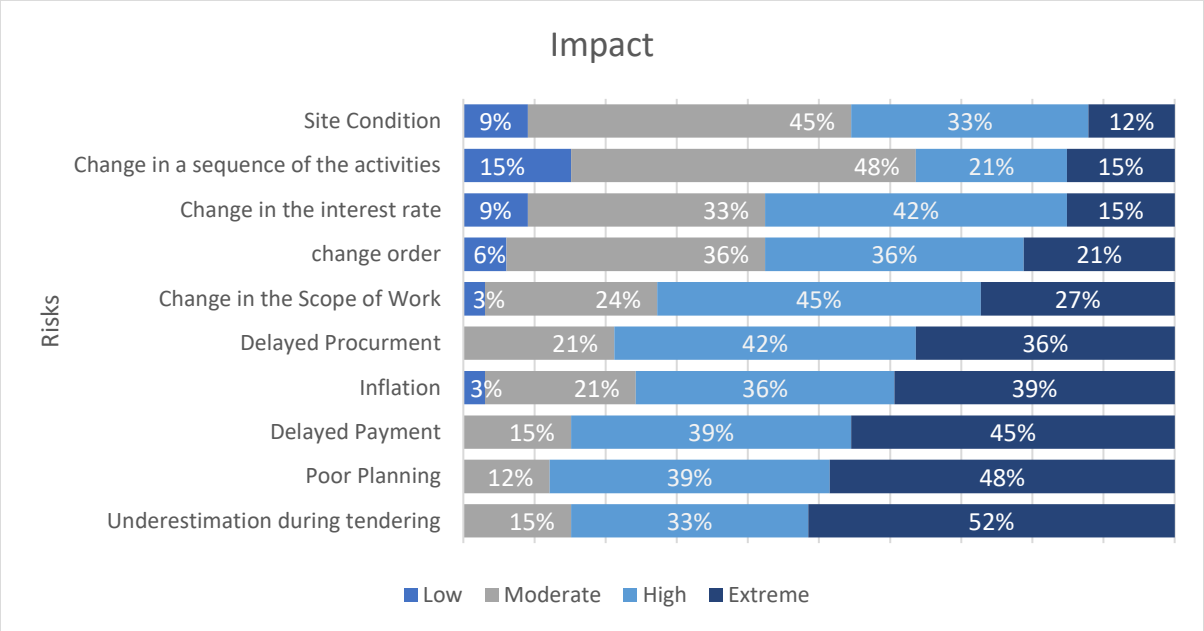

Figure 17 Impact of the event on the project cash flow

In light of the responses mentioned above, the author developed a likelihood vs impact matrix in order to identify the most crucial ones which has high likelihood and impact. As shown in Table 6, the author multiplied the likelihood ratios by the impact ratio in order to know rate the risks based on the highest score as shown below.

Table 6 Likelihood Vs Impact Matrix

Rank	Low impact - Low likelihood	Moderate impact – Neutral Likelihood	High Impact – high likelihood	Extreme impact – very likelihood
Delayed Payment	0%	2%	6%	29%
Poor Planning	0%	3%	11%	22%
change order	1%	7%	11%	8%
Underestimation during tendering	0%	4%	10%	17%
Change in the Scope of Work	0%	7%	12%	8%
Inflation	0%	6%	13%	10%
Delayed Procurement	0%	5%	17%	8%

Change in the interest rate	2%	10%	12%	1%
Change in a sequence of the activities	2%	15%	6%	1%
Site Condition	1%	28%	5%	1%

Accordingly, the author drew the conclusion that the three most prevalent risks in the construction industry were also the most crucial, namely, underestimation during tendering, poor planning, and delayed payment. Accordingly, the author opted to apply these risks to the case study described in the subsequent chapter.

In addition to the mitigation processes outlined by the survey respondents, implementing the risks shall be accompanied by the mitigation measures discussed in the literature review. The author categorised the survey's mitigation processes based on where respondents gained work experience to determine if the location influences the mitigation process.

As shown in Table 6, the categories were Egypt, Finland, Germany, Ghana, India, Mexico, Nigeria, Pakistan, Saudi Arabia, and international, with respondents who worked in more than three countries included in the international category. Since most respondents' experiences were in Egypt, the author was able to gain a deeper comprehension of the mitigation plans implemented in the Egyptian industry, which revealed a diversity of financing strategies.

Table 7 Company's strategies to finance negative cash flow

Country	Responses
Egypt	Bank loan
	Sharing the risk with financial entities like banks, insurance companies and etc.
	Proper planning for a construction project during tendering to optimize the cash flow and schedule and minimize the potential for negative cash flow.
	Using profit from other projects
	Securing an advanced payment from a newly signed project at the earliest to continue working.
	Changing the sequence of the activities and trying complete the activities requiring shorter duration earlier than scheduled to boost the cash flow
Finland	Bring in more capital (loans)
	sell part of the project if done
Germany	Contribute more equity (self fund)

	ask investors for more funding
Ghana	Use out of pocket
	Loan
India	other projects profitability
	self funding
	Explore new suppliers who can provide material on a longer credit.
	Change sequence of activities
	Quantity variation claims.
International	Extended loans facilities
Mexico	Contribute more equity
	ask investors for more funding
	Loans
Nigeria	Proper planning and monitoring
	Use out of pocket
	Loan
	Many companies delay payment of material supplies, workmen wages etc. to keep the project running
Pakistan	Negotiating payment terms
Saudi Arabia	Optimize the production
	Project financing
	To decrease indirect costs and increase productivity.
	Proper Planning
	Loans from banks in the form of LC's
Saudi Arabia/Egypt/Finland	Cost cutting by crashing some other activities or laying off some unnecessary resources and moving them to other projects.
	Changing some materials used in the current tender and trying to replace them with less quality items, but not less than the minimum quality requirements set by the project.

The funding methods obtained by the respondents demonstrated that the mitigation method was not attributable to location, and the majority of the findings concerned self-funding, loans, sharing risks with other financial entities, rescheduling the activities, investing the payments of other projects on the one at risk, back-to-back payment terms with suppliers and subcontractors, and optimising the cash flow and schedule during tendering or prior to the start of construction.

As a result of the literature review concluding that cash flow optimisation is a preventive action, respondents were asked to share the optimisation methods used by their companies, as shown in Table 7 below.

Table 8 Optimization methods for cash flow

Country	Response
Egypt	Cash flow planning, financial agreements, back to back contracts
	Cash flow analysis(Estimated) for the duration of the entire project prior to taking on a project
	Cash and quality monitoring , Analysis and controlling
	Advance Payments
Germany	Forecasting
India	Proper Team management for liaisoning, engaging in 3 or more projects at once instead of focusing on a specific one.
	Preliminary Ground Surveys + Proper Estimate + max limit on the loan + Front loaded billing schedules + Insurance
International	Optimizing critical path items and client payments
Mexico	Loans
	Forecasting
Nigeria	Monitoring
	Negotiate quick payment term and maintain cash flow forecast
	Efficient planning and monitoring of various tasks in a project
	Use out of pocket
Pakistan	Train Project Manager on Cash flow. Strong Planning, processing change orders quickly
Saudi Arabia	Resource planning and higher production
	Banking channels & financing based on the projects cash flow
	Try to support the cash flow by other projects in hand.
	Reserve funds for the particular project.
	Proper Planning and a competent and independent PMO office
USA	Enforcing contract terms regarding payment timing

Companies used optimisation methods such as amending payment terms in the contract with the client and with suppliers and subcontractors, advance payment, cost control throughout the project duration, optimising critical activities, enhancing project team capabilities, self-funding, and using payments from other projects to support the project at risk.

The author asked respondents if current industry standards and best practices successfully manage the risks of negative cash flow in order to determine the applicability of current optimisation and mitigation measures against unexpected and extended negative cash flow. According to Fig.18, 82% of respondents believe current industry standards do not adequately address and prevent unanticipated negative cash flow. On the other hand, only 18% of respondents agreed that the current standards efficiently tackle the risks of negative cash flow. Their prior

experience was based in Egypt, India, and Saudi Arabia, and they all worked in management-related disciplines.

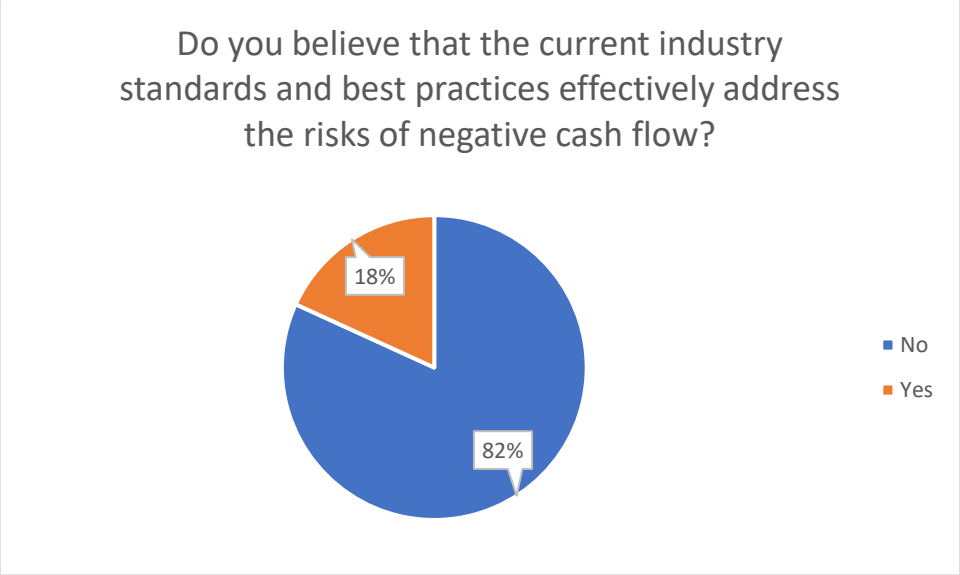

Figure 18 Participants' opinion regarding the efficiency of the current standards

The author concluded that respondents who disagreed that current standards are efficient, as many companies are still struggling with negative cash flow due to lack of knowledge of the methods, lack of information provided by the client during tender, lack of communication between clients and contractors, and traditional management system that cannot deal with unforeseen conditions such as economic crisis. Respondents who thought that current standards are efficient, on the other hand, believed that they need to be applied adequately and that implementation varies depending on the project team's capabilities.

The author concluded that further justification was required to assure the efficiency of the optimization methods obtained through the survey and the conducted literature review. Accordingly, the author decided to conduct a case study to optimize the cash flow and mitigate the prolonged negative cash flow, and the following question, illustrated in Fig. 19, was asked to comprehend the acceptable range for the negative cash flow in the market in order to be able to measure the success of the case study.

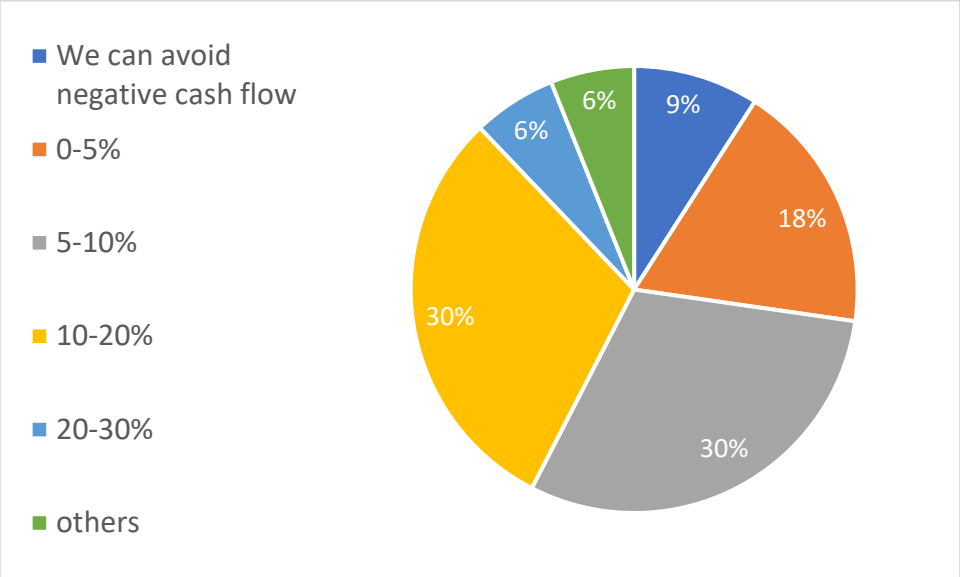

Figure 19 Accepted range for the negative cash flow out of the total value of the project

The respondents were asked if the negative cash flow was preventable and, if not, what percentage of the negative cash flow should be compared to the entire value of the project. Because 60% of respondents agreed that the maximum percentage of negative cash flow should be between 5% and 20% of the entire project value; as a result, the successful optimisation strategy will minimise the negative cash flow by 5% to 20% of the overall project value.

In addition to knowing the acceptable percentage of the negative cash flow, the author asked respondents about the scale of construction companies that suffer the most from unexpected and negative cash flow, and respondents were able to select more than one category. As illustrated in Table 8, small and medium-scale companies are the ones who suffer the most from negative cash flow; as a result, these businesses are in desperate need of a negative cash flow mitigation plan.

Table 9 Companies that are at extreme or high risk against unexpected and negative cash flow

Response	No. of votes
small scale companies	18
Medium scale companies	13
Large scale companies	7
it does not matter	6

3.3 Survey Conclusion

Based on the previously collected data and analysis, the author concluded that the most prevalent risks encountered by construction project teams have a high likelihood, and their impacts on project cash flow are considered extreme. These were the risks:

- Underestimation during tender indicates that the contractor does not consider all costs during the project's tendering process; as a result, the contractor may experience financial challenges throughout work execution, resulting in a protracted negative cash flow.
- Poor planning indicates that the contractor failed to manage site operations such as material delivery, coordination of site activities, poor monitoring of site progress, and poor project management. Poor planning results in inefficient financial and time management for the project, resulting in additional delays and/or protracted and unanticipated negative cash flow.
- Delayed payment, which 67% of respondents thought is the most common risk jeopardising the project's cash flow. When the client approves the work and the invoice submitted by the contractor but fails to pay the accepted amount of money within the agreed-upon time frame, the contractor confronts delayed payment. Such an event puts the contractor in a position where he has little choice except to cease work or fund the project out of his own pocket, which worsens the contractor's financial situation.

In addition to identifying risks, the survey highlighted numerous risk mitigation and optimisation approaches that companies use to overcome or manage unexpected and prolonged negative cash flow. The following approaches of mitigation and optimisation were used:

- Self-funding or financing the project at risk with funds collected from other projects. This method is suitable for large-scale companies with adequate liquidity due to the scope and number of projects handled. However, such a method is not considered feasible for small and medium-sized companies, given that these businesses typically operate on tight budgets. Financing projects at risk through self-funding or payments from other projects may worsen the company's financial situation and lead to bankruptcy.

- Loans or risk sharing with financial institutions such as insurance companies or banks. This approach is attributed to local legislation where the company or project is based, the difference between the project's interest rates and profit margins, and insurance policies accessible in the country where the project or company is located.
- Amending the payment conditions in the contractor's and supplier's contracts to be on a back-to-back basis indicates that the contractor will not pay the supplier or subcontractor until the client pays the contractor the agreed amount. This practice is deemed unjust to subcontractors and suppliers because the contractor shifts the entire risk to the subcontractor or supplier who does not have a contractual arrangement with the customer. As a result, the contractor may obtain exorbitant quotes from suppliers and subcontractors to mitigate such risk, which neither the contractor nor the client desires. On the other hand, the contractor modifies the payment terms from his/her side to encourage the client to pay earlier by establishing an incentive scheme stating that the client can receive a discount on the invoice if the client pays earlier than the contractually agreed upon date. For instance, the client and the contractor agree that payment must be received 45 days after the invoice approval date; however, the client can pay 95% of the total invoice value if payment is made within 15 days of the invoice approval date or 98%, if payment is made within 30 days and in both cases the liability of the client towards this invoice, will be ceased after such payment. Such a method may reduce the contractor's profit margin but improves cash flow and financial liquidity, allowing the contractor to invest in other activities or projects if feasible.
- Effective cost control in tandem with accurate forecasts. Such mitigation and optimisation methods begin during the tendering phase when the contractor plans for the activities and cash flow management tactics used throughout the project. As a result, this method can provide a forecast for the potential risks and challenges of the project, which can play a significant role in the contractor's decision-making process, and the contractor can reject the project if the risks' consequences exceed the contractor's financial and technical capabilities.

These mitigation and optimisation strategies were used globally based on the responses obtained, with changes based on local financial legislation and the size of the company.

Furthermore, the companies that can benefit the most from mitigation methods against unexpected and prolonged negative cash flow are the ones that suffer the most from it, which are small and medium-sized companies. They should optimise the cash flow to reduce the percentage of the negative cash flow's value compared to the project's total value as low as possible, depending on the company standards.

The author demonstrated the effectiveness of some of the mitigation and optimisation methods discussed in the following chapter by studying a case study of a small to a medium-sized company facing the three most common risks that lead to unexpected negative cash flow, as well as the mitigation methods used by the company to mitigate these risks.

4 Case Study

Since the risks and methods for mitigating them were demonstrated through a literature review and survey conducted with the assistance of construction experts, a case study was conducted to demonstrate the applicability of these approaches with regard to the three most prevalent risks. In light of the aforementioned survey data, the author decided to apply the case study to a small-scale company, as most respondents concurred that small scale companies are most affected by negative cash flow. In addition, the author separated the case study into three scenarios, each addressing one of the three risks. The author then implemented the applicable mitigation and optimisation techniques. Some of the specific mitigation and optimisation techniques were inapplicable since the case study involved a small-scale company. There are a variety of techniques that may not be viable due to the scale of the company. For instance, the practice of long-term self-funding, in which the contractor covers the negative cash flow throughout the project, may prove impractical for smaller companies due to their limited financial resources. Additionally, relying on payments from other projects to finance the current project may be risky, especially if the company lacks the necessary workforce to manage multiple projects simultaneously. Finally, smaller companies may not be able to modify the client's payment terms, as they lack the bargaining power necessary to impose their own terms.

Accordingly, the author implemented mitigating measures such as

- during the construction phase, the contractor obtained a loan from a bank for financing.
- the contractor provided a discount on the invoice for early payment after amending the payment terms.
- the contractor decided to invest a small portion of their equity for a brief period. This investment will not exceed 20% of the total contract price..

The case study illustrated the effects of delayed payment, tender underestimation, and poor planning on the cash flow, as measured by the cumulative value of the negative cash flow and the total value of the monthly negative net payment.

In accordance with (Halpin & Senior, 2009), the cash flow was depicted in S-curve graphs for the cumulative value of the outgoing disbursement flow and the receipts cash flow. In contrast, the cumulative net cash flow and net monthly payments were depicted separately to highlight the distinctions between the curves.

The payments will be determined by subtracting the advance payment percentage from each interim payment, in addition to the retention percentage, according to the following equation.

Monthly Payment Value = Value Earned – [Value Earned x (Retention Percentage + Advance Payment Percentage)]

After obtaining the cash flows incorporating the impact of the risks, the author employed three mitigation scenarios for each risk to illustrate the distinctions between these mitigation methods and their effectiveness in mitigating each risk.

4.1 Assumptions

Prior proceeding with the case study, the author decided to fix few assumptions for all scenarios to be able to determine and comprehend the impact of each risk on the same project. The assumptions were based an existing project and they included location of the project, scale of the company, base value of the project, the base schedule of the project, advance payment value, retention percentage and bank interest for the bank loan scenario and these assumptions illustrated as shown in Table 10.

Table 10 Case study assumptions

Topic	Assumption
Location of the project	Saudi Arabia
Scale of the company	Small scale
Value of the project	20,000,000 SAR*
Contract type	Remeasured Unite Rate
Payment terms	45 days from the completion work
Advance payment percentage	10%
Retention percentage	10%
Bank interest	3.67%
Bank Instalment	Monthly
Duration for bank Instalment	12 months
Maximum percentage for loan	20% of project value
Maximum percentage for equity	20% of project value*
Start Date	13th August 2022
End Date	16th March 2023
Total Duration	215 days
Payment of Retention	6 months after the completion date

note (*)Author Assumption

Besides these assumptions, the base line schedule of the project was developed on weekly basis as shown below.

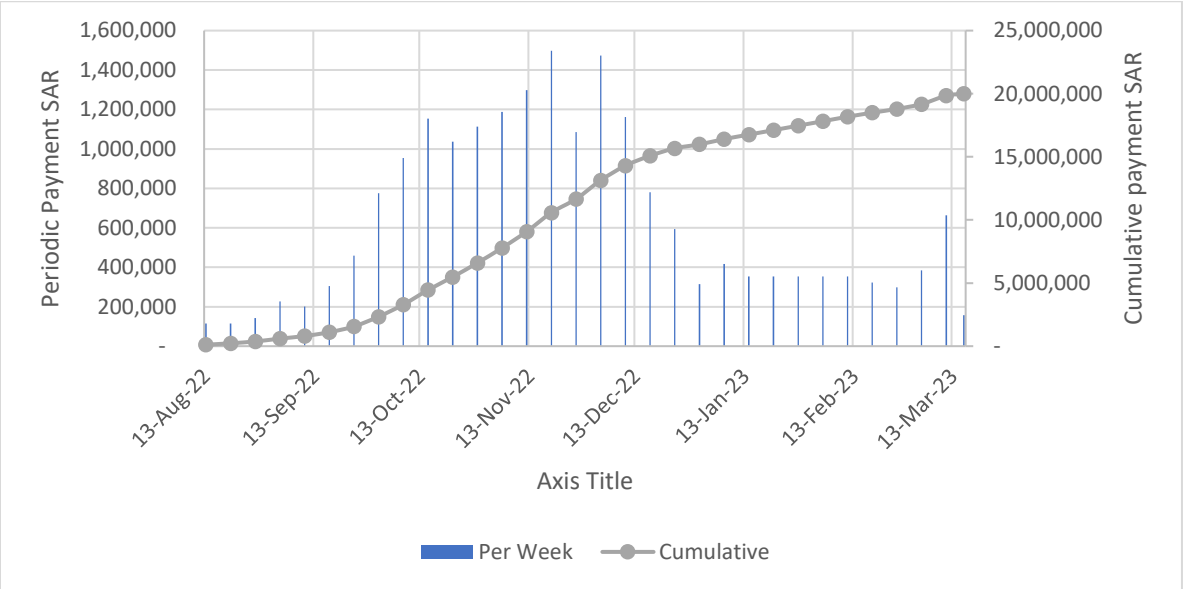

Figure 20 Weekly cash flow

As a result, the author developed a monthly schedule that reflected the monthly costs and applied the risk and mitigation scenarios to this schedule. As depicted in Figure 21, the schedule was subdivided into six primary currency flows, which were

- Periodic cost: the costs incurred by the contractor based on the actual executed work on site. - Cumulative cost: the cumulative value of the costs incurred by the contractor throughout the duration of the project.
- Periodic payment: represented the contractor's receivables for work executed on-site, less 10% of the advance payment and 10% of the retention, which shall be remitted six months after the completion of the construction work.
- Cumulative payment: represented the sum of all monthly payments received by the contractor throughout the duration of the project.
- Net cumulative: the difference between cumulative payments and cumulative expenses
- Periodic net: the difference between periodic payment and cost

In addition to the aforementioned cash flows, the cumulative negative represented the sum of the net cumulative negative value during the construction phase. Alternatively, the total net negative periodic payment represented the sum of the

negative periodic net between the first and last periodic cost. These two values were utilised to distinguish between the risk impact and mitigation scenario values.

As shown in the Figures 22 and 23, the baseline schedule and base cash flow indicated that the contractor began to incur negative cash flow upon the second month of project duration, which was nearly 75% of the duration of the project, and that the cumulative negative cash flow was 35,590,021 SAR and the total net negative periodic payment was 10,361,876 SAR, which represented 178% and 52% of the project value, respectively.

Consequently, the following section discussed the impact of each risk on the cash flow and the impact was evaluated with reference to the values of the cumulative negative cash flow and the total negative payment.

Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Periodic cost	371,252	1,192,669	5,032,626	5,067,961	4,323,809	1,478,882	1,327,648	1,205,154						
Cumulative cost	371,252	1,563,321	6,596,547	11,664,507	15,988,316	17,467,197	18,794,846	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
Periodic Payment	2,000,000		297,001.25	954,135.36	4,026,100.68	4,054,368.57	3,453,046.30	1,183,105.23	1,062,118.68	964,123.34	-	-	-	2,000,000
Cumulative payment	2,000,000	2,000,000	2,297,001	3,251,137	7,277,237	11,331,606	14,790,653	15,973,758	17,035,877	18,000,000	18,000,000	18,000,000	18,000,000	20,000,000
Net Cumulative	1,628,748	436,079	(4,299,545)	(8,413,371)	(8,711,079)	(6,135,592)	(4,004,193)	(4,026,242)	(2,964,123)	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)	-
Periodic Net	1,628,748	(1,192,669)	(4,735,625)	(4,113,825)	(297,708)	2,575,487	2,131,399	(22,049)	1,062,119	964,123	-	-	-	2,000,000
Cumulative negative	(35,590,021)	178%												
Sum of Negative Payment	(10,361,876)	52%												

Figure 21 Basic Project schedule and costs

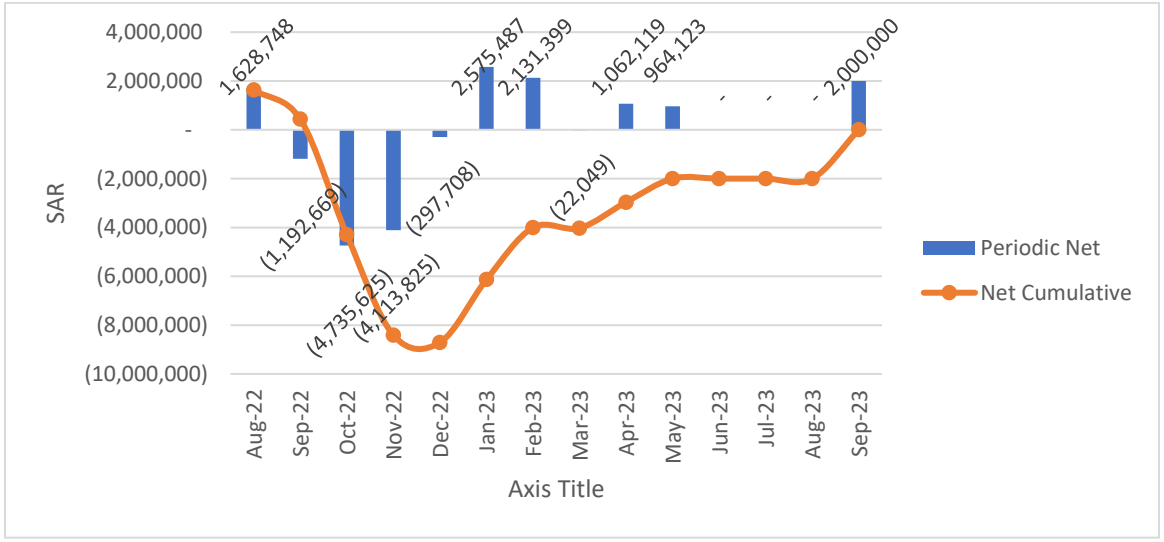

Figure 22 Periodic Net Vs Cumulative Net

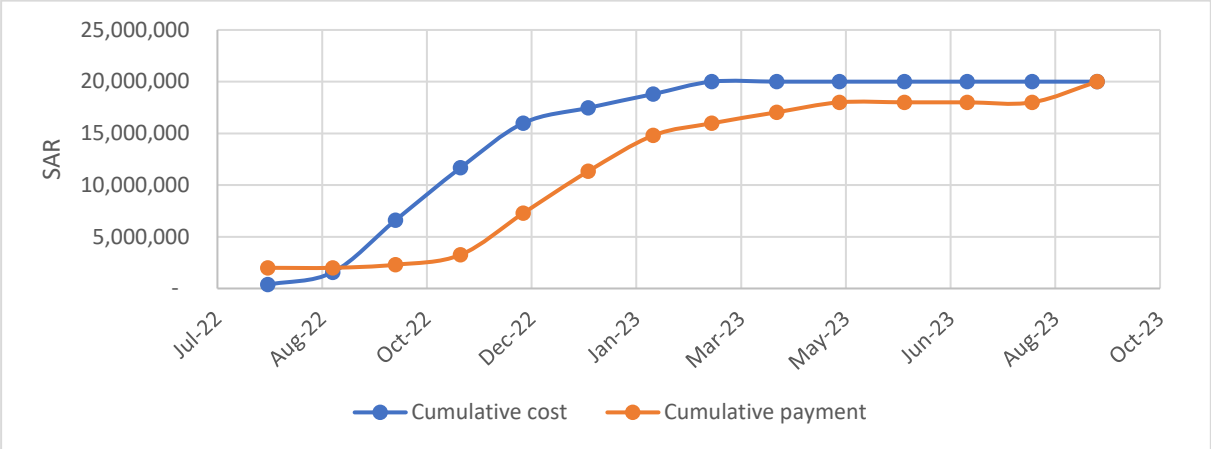

Figure 23 Base Cash Flow

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4.2 Risk Implementation

In this section, the implications of each risk were broken down in detail, and based on how those implications would play out in terms of the cumulative negative cash flow and total negative payment, the worst-case scenario that would result in the lowest value for the cumulative negative cash flow was selected as the one to be mitigated in the subsequent section.

4.2.1 Underestimation

In this part the author assumed that the contractor underestimated the cost incurred by 20 percent of the planned value; however, the contractor would receive the incurred costs within the periodic payment and the total value would change accordingly.

The author applied the 20 percent increase in cost on each month starting from the third month as the net cumulative value of the first two months were not negative; afterwards, the author compared the change in the cumulative negative value as shown in table 11.

Table 11 the underestimation per month scenarios

Modified Month	Updated Negative Cumulative	%	Updated Negative Periodic	%
Base	(35,590,021)	178%	(10,361,876)	52%
October 2022	(38,408,292)	192%	(11,070,693)	55%
November 2022	(38,225,361)	191%	(11,375,468)	57%
December 2022	(37,665,450)	188%	(11,226,638)	56%
January 2023	(36,240,729)	181%	(10,339,827)	52%
February 2023	(36,121,081)	181%	(10,361,876)	52%
March 2023	(35,831,052)	179%	(10,602,907)	53%

As shown in the table above, it could be concluded that the underestimation of the work executed during October led to the highest negative net cash flow and its schedule and cash flow shall be as shown in figures 24, 25 and 26.

Base														
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Periodic cost	371,252	1,192,669	6,039,151	5,067,961	4,323,809	1,478,882	1,327,648	1,205,154						
Cumulative cost	371,252	1,563,921	7,603,072	12,671,032	16,994,841	18,473,723	19,801,371	21,006,525	21,006,525	21,006,525	21,006,525	21,006,525	21,006,525	21,006,525
Periodic Payment	2,000,000		297,001.25	954,135.36	4,831,320.82	4,054,368.57	3,459,046.90	1,183,105.23	1,062,118.68	964,123.34	-	-	-	2,000,000
Cumulative payment	2,000,000	2,000,000	2,297,001	3,251,137	8,082,457	12,136,826	15,595,873	16,778,978	17,841,097	18,805,220	18,805,220	18,805,220	18,805,220	20,805,220
Net Cumulative	1,628,748	436,079	(5,306,071)	(9,419,896)	(8,912,384)	(6,336,897)	(4,205,498)	(4,227,547)	(3,165,428)	(2,201,305)	(2,201,305)	(2,201,305)	(2,201,305)	(201,305)
Periodic Net	1,628,748	(1,192,669)	(5,742,150)	(4,113,825)	507,512	2,575,487	2,131,399	(22,049)	1,062,119	964,123	-	-	-	2,000,000
Cumulative negative	(38,408,292)	192%												
Sum of Negative Payment	(11,070,693)	55%												

Figure 24 Oct. Underestimation Schedule

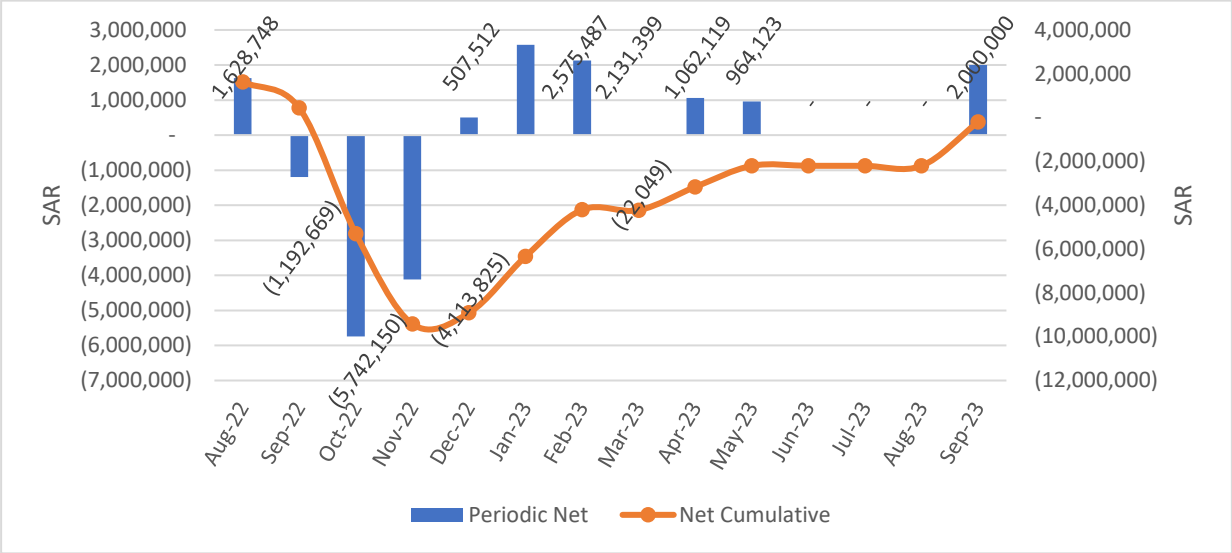

Figure 25 Net Periodic Vs Net Cumulative for the underestimation

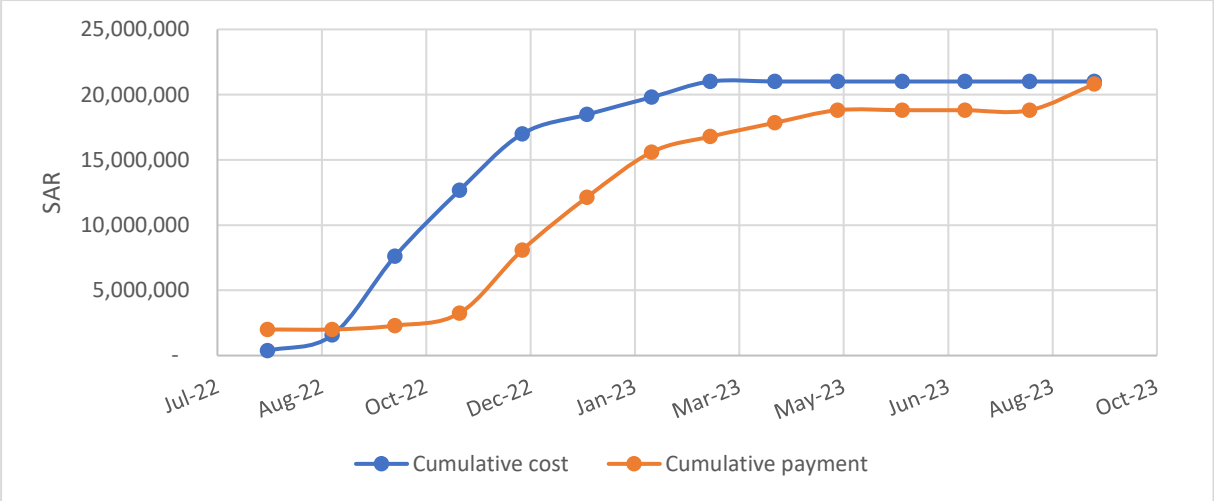

Figure 26 Cumulative Cost and Payment for the underestimation

As a result, the underestimation that occurred during the tender significantly influenced the cumulative negative cash flow because it took place at the primary stage of the project and in the same month that the cumulative negative cash flow began.

4.2.2 Delayed Payment

In this section, the author made the assumption that the employer was late with one of the periodic payments, and instead of paying it as per the contractual payment term, they split it up into two equal instalments that they made over the course of the next two months. Such a scenario was applied to payments collected between

October and March separately, and based on such an implementation; the author followed the worst-case scenario, whose updated net periodic value was the lowest among all scenarios indicated in Table 12.

Table 12 delayed payment scenarios

Delayed Payment	Updated Negative Cumulative	%	Updated Negative Periodic	%
Base	(35,590,021.44)	178%	(10,361,876.05)	52%
October 2022	(36,035,523.31)	180%	(10,361,876.05)	52%
November 2022	(37,021,224.47)	185%	(10,838,943.72)	54%
December 2022	(41,629,172.46)	208%	(14,387,976.73)	72%
January 2023	(41,671,574.29)	208%	(11,818,708.63)	59%
February 2023	(40,778,591.79)	204%	(11,667,475.44)	58%
March 2023	(36,773,126.66)	184%	(11,544,981.27)	58%

According to the implemented scenarios, it was concluded that if the payment for December got delayed and paid in the following two months, the total sum of the negative periodic payment would reach the lowest value, which would be 14,387,976 SAR, which is 72% of the contract value. It affected the payment schedule and cash flow, as shown in Figures 27, 28, and 29.

Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Periodic cost	371,252	1,192,669	5,032,626	5,067,961	4,323,809	1,478,882	1,327,648	1,205,154						
Cumulative cost	371,252	1,563,921	6,596,547	11,664,507	15,988,316	17,467,197	18,794,846	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
Periodic Payment	2,000,000		297,001.25	954,135.36		6,067,418.91	5,472,097.24	1,183,105.23	1,062,118.68	964,123.34	-	-	-	2,000,000
Cumulative payment	2,000,000	2,000,000	2,297,001	3,251,137	3,251,137	9,318,556	14,790,653	15,973,758	17,035,877	18,000,000	18,000,000	18,000,000	18,000,000	20,000,000
Cumulative Net	1,628,748	436,079	(4,299,545)	(8,413,371)	(12,737,179)	(8,148,642)	(4,004,193)	(4,026,242)	(2,964,123)	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)	-
Periodic Net	1,628,748	(1,192,669)	(4,735,625)	(4,113,825)	(4,323,809)	4,588,537	4,144,449	(22,049)	1,062,119	964,123	-	-	-	2,000,000
Cumulative negative	(41,629,172)	208%												
Sum of Negative Payment	(14,387,977)	72%												

Figure 27 Dec. delayed payment schedule

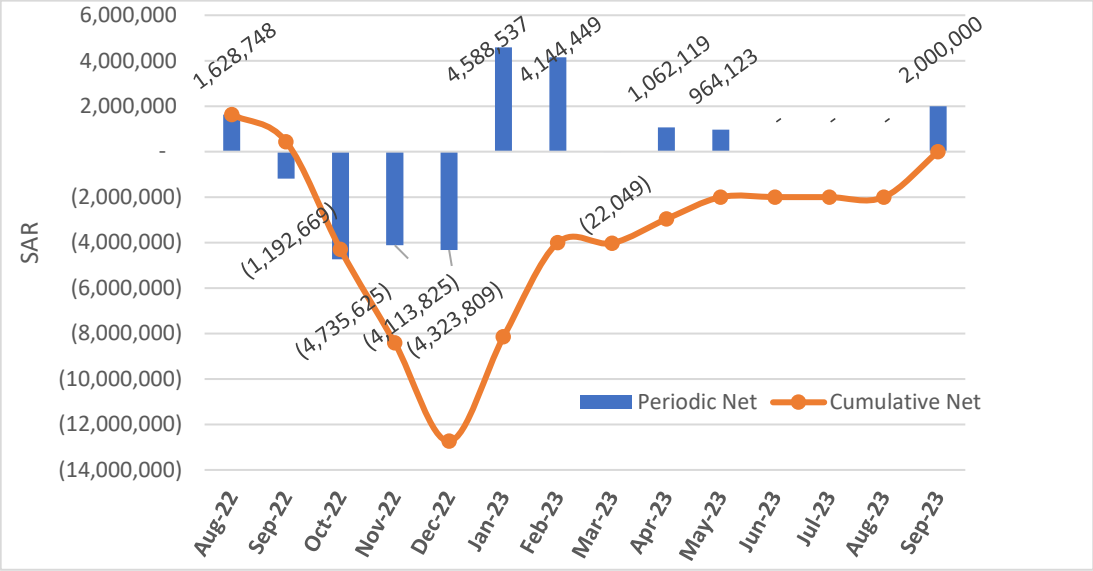

Figure 28 Net Periodic Vs Net Cumulative for Delayed Payment

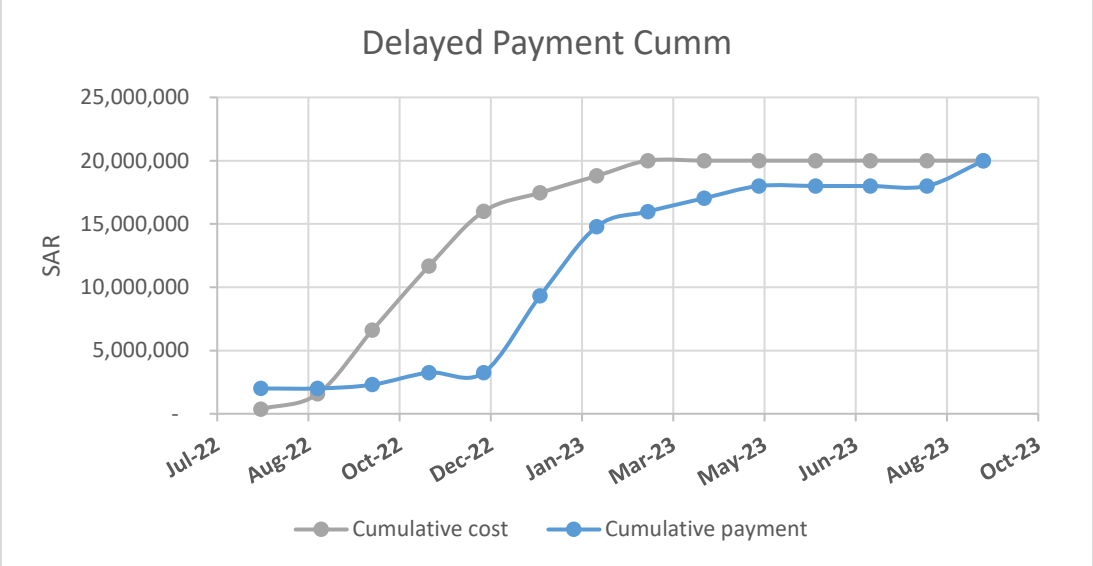

Figure 29 cumulative cost vs cumulative payment for delayed payment

In addition, the delayed payment has the most significant impact on the negative cash flow when it occurs during a transition phase in which the net cumulative cash flow begins to improve by overcoming the negative impact on it. This is the case when the delayed payment most impacts the negative cash flow.

4.2.3 Poor Planning

In this section, the author obtained an actual scenario that occurred throughout the project so that the author could study the effect of poor planning on cash flow. The contractor delayed the mobilisation by one week from the planned one, and it did not

begin until the 20th of August, 2022. In addition to the delayed mobilisation, the contractor's progress was less than the projected progress, which caused the contractor to finish the project in July 2023 rather than March 2023. Figure 30 illustrates the poor performance and planning that resulted from this.

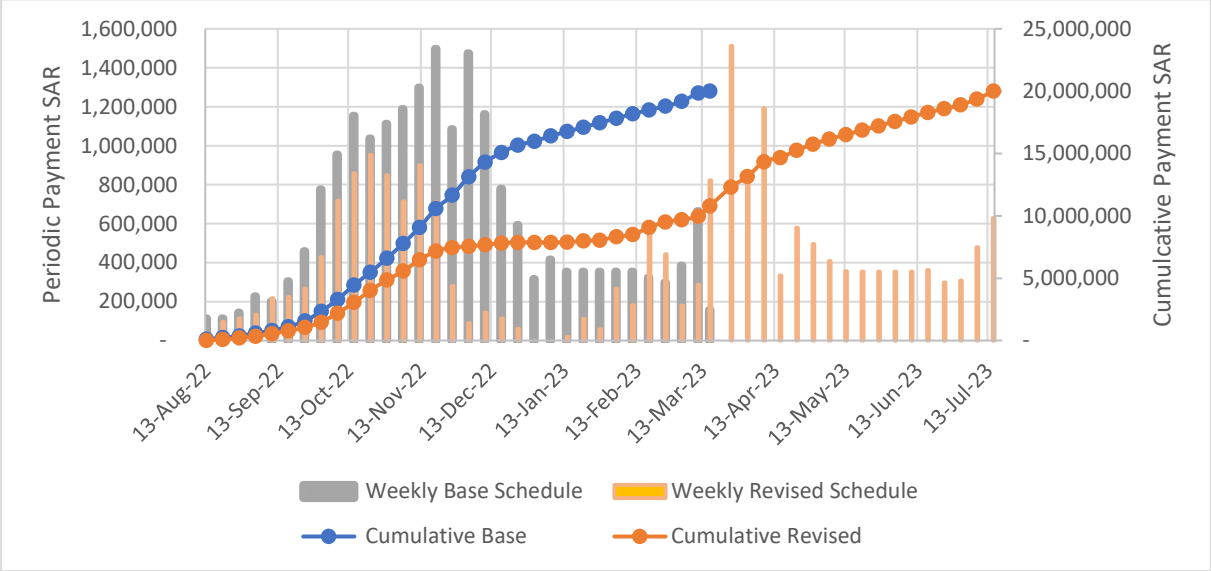

Figure 30 Base Schedule Vs Delayed Schedule

As illustrated in Figure 30, the cash flow of the project was no longer going to follow the traditional s-curve. Furthermore, the contractor would bear the costs until July 2023, and the assumed costs will remain the same amount of 20,000,000 SAR throughout the project.

According to the changes occurred to the weekly schedule the updated monthly payment schedule and cash flow were changed and the total retained amount shall be paid by January 2024 as shown on Figures 31,32 and 33.

As shown in Figure 31, the cumulative negative cash flow became less than the baseline schedule which was 34,187,035 SAR instead of 35,590,021 SAR and total sum of negative payments became more than the baseline one by 2,332,932 SAR with total value of 12,694,808 SAR instead of 10,361,876 SAR.

Base																		
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24
Periodic cost	209,413	838,594	3,808,301	2,602,469	408,226	187,977	1,459,766	2,799,633	3,433,054	1,471,780	1,367,191	1,413,597						
Cumulative cost	209,413	1,048,007	4,856,308	7,458,777	7,867,003	8,054,980	9,514,746	12,314,379	15,747,432	17,219,212	18,586,403	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
Periodic Payment	2,000,000		167,530.39	670,875.34	3,046,640.91	2,081,974.94	326,580.61	150,381.61	1,167,813.06	2,239,706.02	2,746,443.04	1,177,423.91	1,093,752.94	1,130,877.23				2,000,000
Cumulative payment	2,000,000	2,000,000	2,167,530	2,838,406	5,885,047	7,967,022	8,293,602	8,443,984	9,611,797	11,851,503	14,597,946	15,775,370	16,869,123	18,000,000	18,000,000	18,000,000	18,000,000	20,000,000
Cumulative Net	1,790,587	951,993	(2,688,778)	(4,620,371)	(1,981,956)	(87,958)	(1,221,144)	(3,870,395)	(6,135,636)	(5,367,709)	(3,988,458)	(4,224,630)	(3,130,877)	(2,000,000)	(2,000,000)	(2,000,000)	(2,000,000)	-
Periodic Net	1,790,587	(838,594)	(3,640,771)	(1,931,593)	2,638,415	1,893,998	(1,133,186)	(2,649,251)	(2,265,241)	767,926	1,379,252	(236,173)	1,093,753	1,130,877	-	-	-	2,000,000
Cumulative negative	(34,187,035)	171%																
Sum of Negative Payment	(12,694,808)	63%																

Figure 31 Payment and cost schedule for delayed schedule

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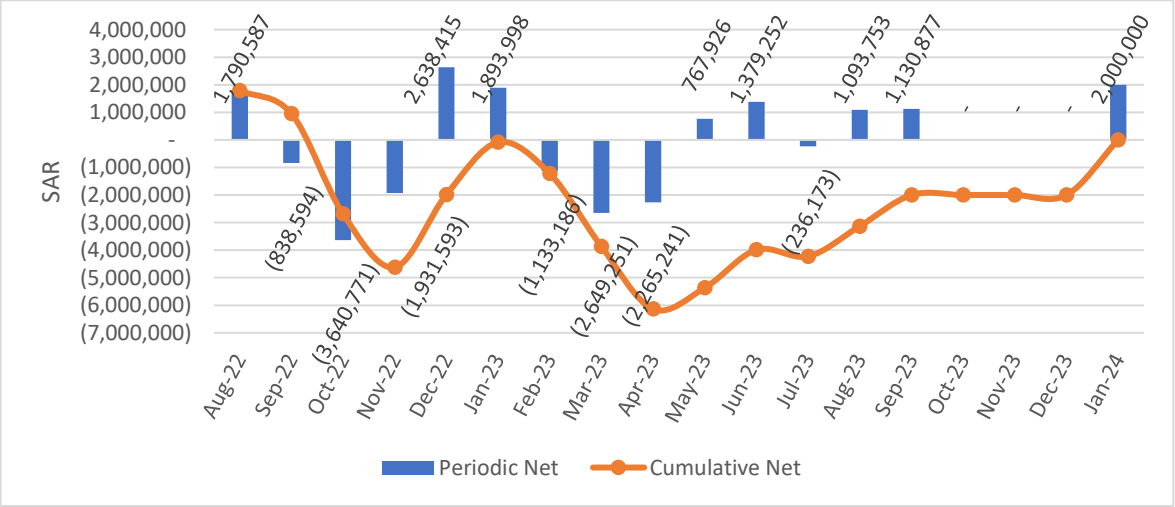

Figure 32 Periodic Net Vs Cumulative Net for poor planning scenario

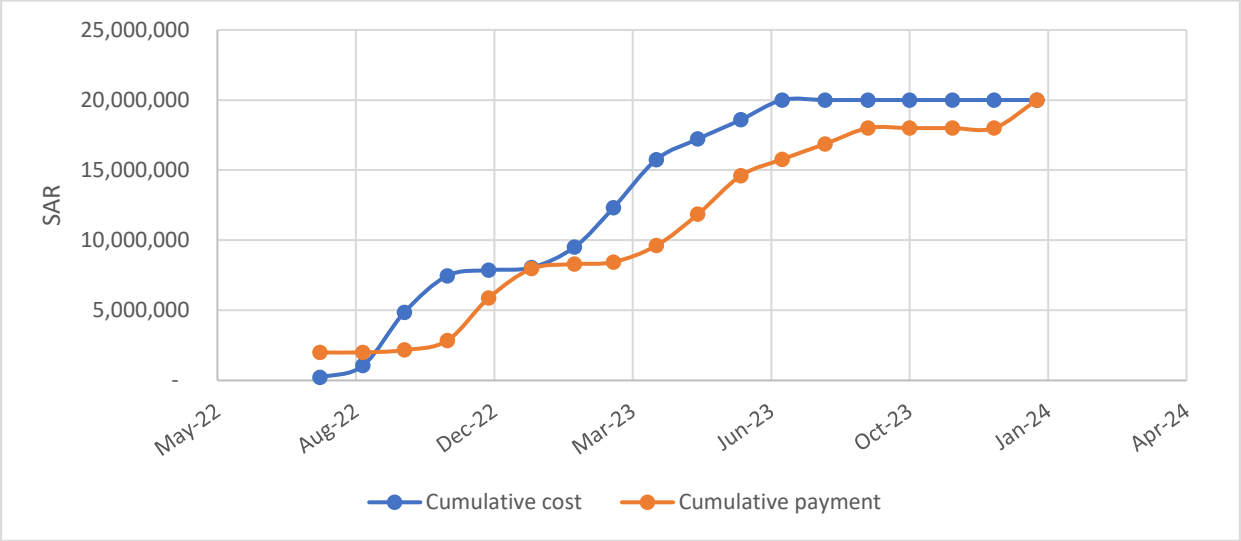

Figure 33 Cumulative cost Vs Cumulative payment for poor planning scenario

Although the cumulative negative cash flow was reduced by 1,401,987 SAR, the sum of the negative payment during the execution period increased by 2,332,932 SAR.

4.3 Mitigation Methods

According to the information presented above, the risks had a remarkable impact on the cumulative negative cash flow and the negative payments that occurred during the construction period. After that, the author developed Table 13 to illustrate the impact of the underestimation, delayed payment, and poor planning on the negative cash flow of the baseline schedule by using cumulative negative cash flow and the total value of the negative payment during the execution duration as a reference for the impact of the risks.

Table 13 Summary for the impact of the risks

Case	Cumulative Negative Cash Flow	% to Baseline	Sum of the Negative Payments	% to Baseline
Baseline Value	(35,590,021.44)		(10,361,876.05)	
Oct. Underestimation	(38,408,291.91)	8%	(11,070,693.27)	7%
Dec. Delayed Payment	(41,629,172.46)	17%	(14,387,976.73)	39%
Poor Planning	(34,187,034.77)	-4%	(12,694,808.25)	23%

As a consequence of this finding, one can get the following conclusion: delayed payment was the factor that had the most substantial influence on the overall

cumulative negative cash flow and the total amount of negative payments made during the construction period.

This chapter introduced the mitigation methods concluded by the survey, illustrated in chapter three, in order to evaluate the efficacy of the mitigation methods concerning the risk encountered in the project. These mitigation methods include investing a portion of the contractor's equity, taking out bank loans, and amending the payment terms against deduction for the early payment.

The author assumed that the contractor was able to take a loan from a bank in Saudi Arabis and this loan shall be paid through 12 equal instalments and shall be paid monthly with monthly interest rate 3.67% and the total value of the loan shall not exceed 20% of the total value of the contract. Moreover, the total value of the contractor’s equity that shall be invested in the project shall not exceed 20% of the project value and the contractor would repay the equity through 12 equal payments and these payments were paid monthly. The last assumption was that the contractor would apply after 5% deduction on the early payment which shall be paid within 30 days from the completion of works instead of the agreed 45 days.

4.3.1 Mitigation for the Underestimation

During the tender process, the contractor discovered that their initial cost estimates were inadequate leading to 20% increase in the planned cost for October works. Accordingly, the cash flow was negatively affected by such event leading to 8% increase in the total cumulative negative cash flow and 7% to the sum of net negative periodic payment during the construction phase of the project.

The contractor adopted three mitigation scenarios which were taking loans from the bank, changing payment terms by offering deduction to the early payment or investing from the contractor’s equity. Therefore, this section discussed impact of these mitigation methods on the negative cash flow, how it affected the total negative payments and cumulative negative cash flow during the construction phase.

Loans for Underestimation

During the tender process, the contractor discovered that their initial cost estimates were inadequate. To mitigate this impact, they determined that securing a bank loan was necessary. The loan amount approved was 4,000,000 SAR, which will be repaid in 12 monthly instalments of 339,997 SAR. Additionally, the contractor considered that loan was a proactive measure to minimize the overall negative payment amount.

Accordingly, the author implemented various scenarios for the loan to determine the exact month that contactor shall receive the bank loan and to minimize the value of the total net negative periodic payment as much as possible as shown in Table 14.

Table 14 Loan scenarios to mitigate underestimation

Bank Loan Received	Updated Net Cumulative	%	Updated Net Periodic	%
Base Underestimation	(38,408,292)	192%	(11,070,693)	55%
September 2022	(21,548,225.10)	108%	(10,898,014.53)	54%
October 2022	(19,508,244.19)	98%	(7,750,686.91)	39%
November 2022	(21,808,260.10)	109%	(21,808,260.10)	109%
December 2022	(24,448,272.82)	122%	(11,410,690.09)	57%
January 2023	(27,428,282.37)	137%	(11,410,690.09)	57%

Since the contractor was able to the achieve the minimum negative cumulative cash flow when the bank loan was received in September, the author developed payment schedule, Figure 34, for such scenario in order to be compared with other mitigation scenarios.

As illustrated in Figure 35 and 36, the gap between the cumulative payment and cumulative cost was significantly reduced compared to the baseline schedule. However, the contractor still incurred negative cash flow throughout the duration of construction phase.

Loan														
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Bank Payment			4,000,000											
Bank Costs			-	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)
Updated Cumulative Cost	371,252	1,563,921	7,603,072	13,011,029	17,674,835	19,493,713	21,161,358	22,706,509	23,046,506	23,386,503	23,726,500	24,066,497	24,406,493	24,746,490
Updated Cumulative Payment	2,000,000	2,000,000	6,297,001	7,251,137	12,082,457	16,136,826	19,595,873	20,778,978	21,841,097	22,805,220	22,805,220	22,805,220	22,805,220	24,805,220
Updated Cumulative Net	1,628,748	436,079	(1,306,071)	(5,759,893)	(5,592,377)	(3,356,887)	(1,565,485)	(1,927,531)	(1,205,409)	(581,283)	(921,280)	(1,261,276)	(1,601,273)	58,730
Updated Periodic Net	1,628,748	(1,192,669)	(1,742,150)	(4,453,822)	167,515	2,235,490	1,791,402	(362,046)	722,122	624,127	(339,997)	(339,997)	(339,997)	1,660,003
Cumulative negative	(19,508,244)	98%												
Sum of Negative Payment	(7,750,687)	39%												

Figure 34 updated payment schedule for loan against Oct. underestimation.

As shown in the figure above, the total net negative accumulative cash flow during the construction period reached a value of 19,508,244 SAR which helped the contractor to reduce the total negative net cumulative by 18,900,047 SAR with 49.2%.

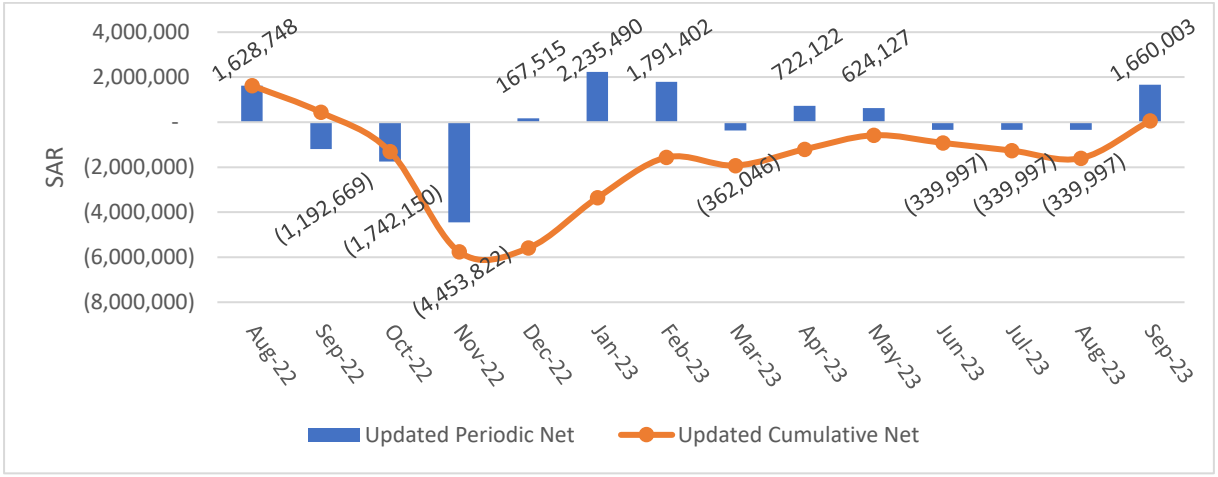

Figure 35 Mitigated Periodic and Cumulative Net for Oct. Underestimation (October Loan)

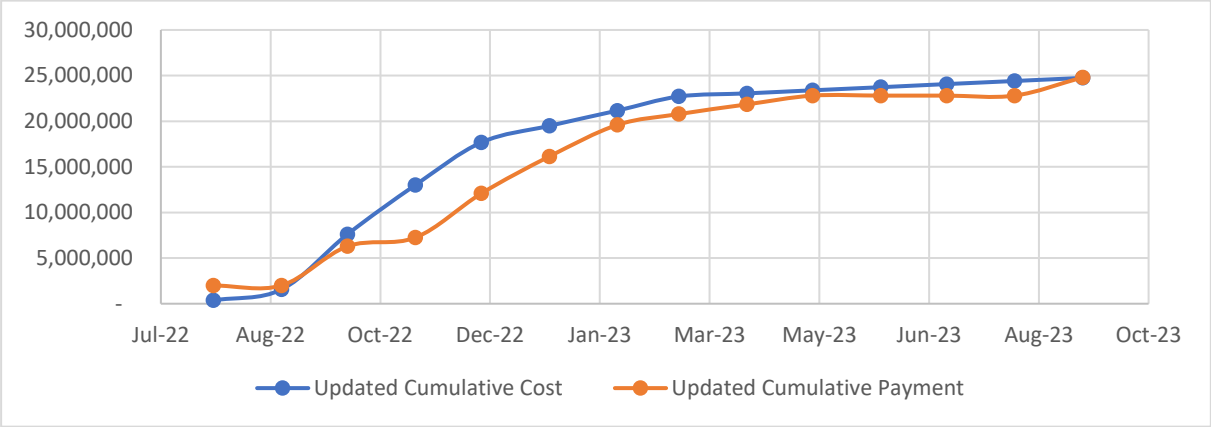

Figure 36 Mitigated Cumulative Cost and Payment Cash Flows for Oct. Underestimation (October Loan)

Equity for the Underestimation

This part discussed the impact of investing part of the contractor's equity in order to mitigate the negative cash flow, and the value of such invested equity shall not exceed 20% of the contract value. This percentage was determined based on the maximum value could the bank finance the project through a loan, as the bank provided loan with value of 20% of the contract value.

In light of the loan scenario, the contractor developed a payment schedule where the equity was invested in October in order to determine the difference between investing equity and bank loans for the same risk.

As shown in Figure 38 and 39, the contractor would face negative cash flow for the throughout the construction phase with 49.5% improvement compared to the underestimated payment schedule and 30.1% improvement to total net negative periodic payment during the construction phase.

Equity														
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Equity Investiment			4,000,000											
Equity Cost				333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333
Updated Cumulative Cost	371,252	1,563,921	7,603,072	13,004,366	17,661,508	19,473,723	21,134,704	22,673,192	23,006,525	23,339,859	23,673,192	24,006,525	24,339,859	24,673,192
Updated Cumulative Payment	2,000,000	2,000,000	6,297,001	7,251,137	12,082,457	16,136,826	19,595,873	20,778,978	21,841,097	22,805,220	22,805,220	22,805,220	22,805,220	24,805,220
Updated Cumulative Net	1,628,748	436,079	(1,306,071)	(5,753,229)	(5,579,050)	(3,336,897)	(1,538,831)	(1,894,214)	(1,165,428)	(534,638)	(867,972)	(1,201,305)	(1,534,638)	132,028
Updated Periodic Net	1,628,748	(1,192,669)	(1,742,150)	(4,447,159)	174,179	2,242,154	1,798,065	(355,382)	728,785	630,790	(333,333)	(333,333)	(333,333)	1,666,667
Cumulative negative	(19,408,292)	97%												
Sum of Negative Payment	(7,737,360)	39%												

Figure 37 Updated Payment Schedule for Equity against Oct. Underestimation

As shown in Figure 37, the total net cumulative negative cash flow during the construction period reached a value of 19,408,292 SAR which helped the contractor to reduce the total net cumulative negative cash flow by 19,000,000 SAR which was the total equity value leading 49.5% improvement. On the other hand, the total sum of negative payment was improved by 30.1%.

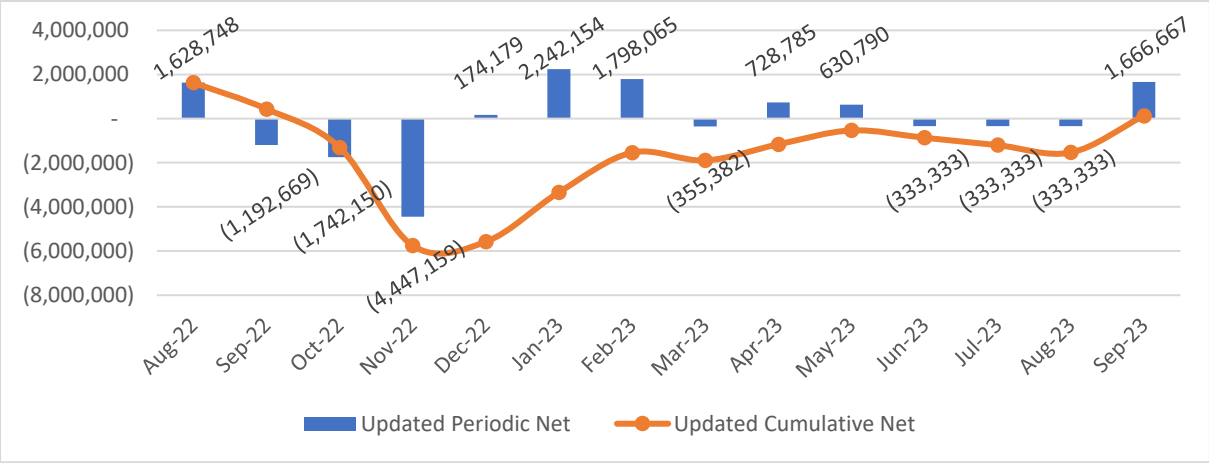

Figure 38 Mitigated Periodic and Cumulative Net for Oct. Underestimation (October Equity)

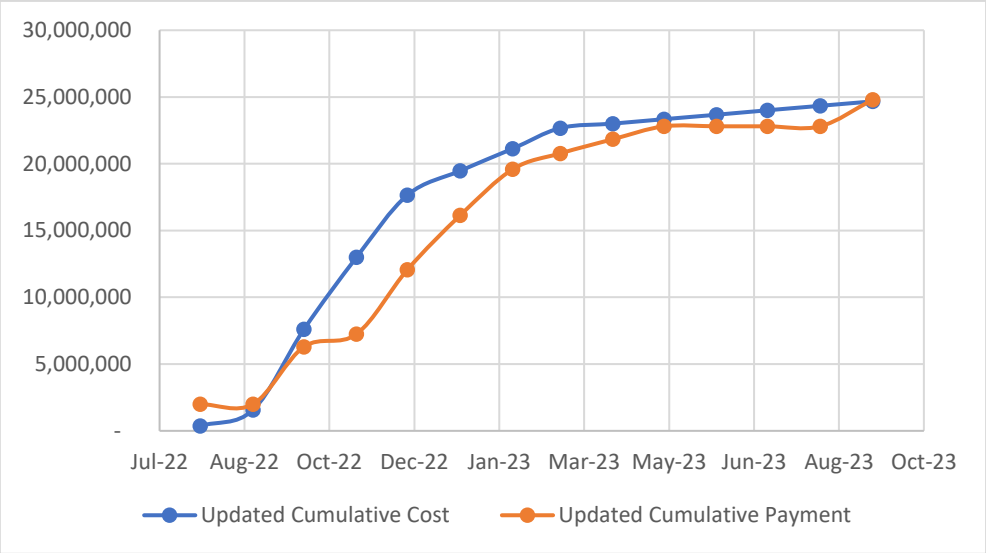

Figure 39 Mitigated Cumulative Cost and Payment Cash Flows for Oct. Underestimation (October Equity)

Amending the Payment Terms for Underestimation

The author developed payment schedule, Figure 40, where the contractor received the payment within 30 days from the completion date of work; accordingly, the contractor was paid on monthly basis with total deduction of 5% of the value of the invoiced work. However, the advance payment and retention shall have remained the same value, which was 2,000,000 SAR each, as the contract value was not amended.

As shown in Figure 40, the total net negative payment during the construction period reached a value of 7,548,220 SAR which helped the contractor to mitigate the total net negative payment by 3,522,473 SAR leading to 32% improvement. On the other hand the cumulative negative cash flow was reduced with total value of 11,688,698 SAR leading to 30% improvement from the baseline schedule. As shown in Figures 41 and 42, although the contractor would face negative cash flow throughout the project duration, the gap between the cumulative costs and cumulative payment was reduced and the total value would lose almost 5.96% due to the amended payment terms; therefore the net cumulative value was concluded with a negative value which was 1,251,631 SAR instead of zero.

Deduction for 30 days	5%

Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Periodic cost	371,252	1,192,669	6,039,151	5,067,961	4,323,809	1,478,882	1,327,648	1,205,154						
Cumulative cost	371,252	1,563,921	7,603,072	12,671,032	16,994,841	18,473,723	19,801,371	21,006,525	21,006,525	21,006,525	21,006,525	21,006,525	21,006,525	21,006,525
Periodic Payment	2,000,000	278,438.67	894,501.90	4,529,363.27	3,800,970.53	3,242,856.47	1,109,161.15	995,736.26	903,865.63	-	-	-	-	2,000,000
Cumulative payment	2,000,000	2,278,439	3,172,941	7,702,304	11,503,274	14,746,131	15,855,292	16,851,028	17,754,894	17,754,894	17,754,894	17,754,894	17,754,894	19,754,894
Updated Net Cumulative	1,628,748	714,518	(4,430,131)	(4,968,729)	(5,491,567)	(3,727,592)	(3,946,079)	(4,155,497)	(3,251,631)	(3,251,631)	(3,251,631)	(3,251,631)	(3,251,631)	(1,251,631)
Updated Periodic Net	1,628,748	(914,231)	(5,144,649)	(538,597)	(522,838)	1,763,975	(218,487)	(209,418)	903,866	-	-	-	-	2,000,000
Cumulative negative	(26,719,594)	134%												
Sum of Negative Payment	(7,548,220)	38%												

Figure 40 Updated Payment Schedule for Amended Payment Terms against Oct. Underestimation

.

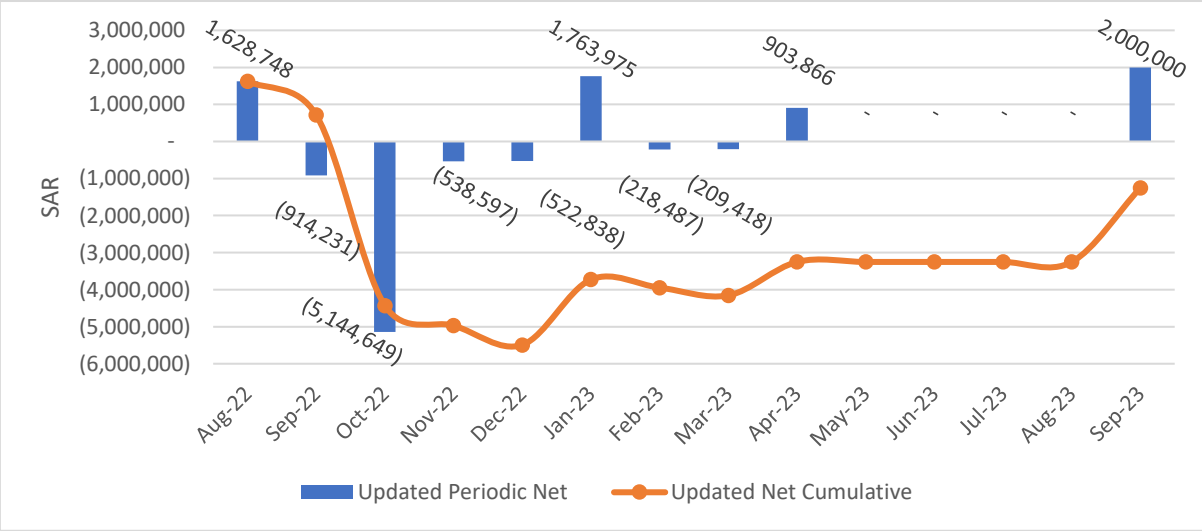

Figure 41 Mitigated Periodic and Cumulative Net for Oct. Underestimation (Amended Payment Terms)

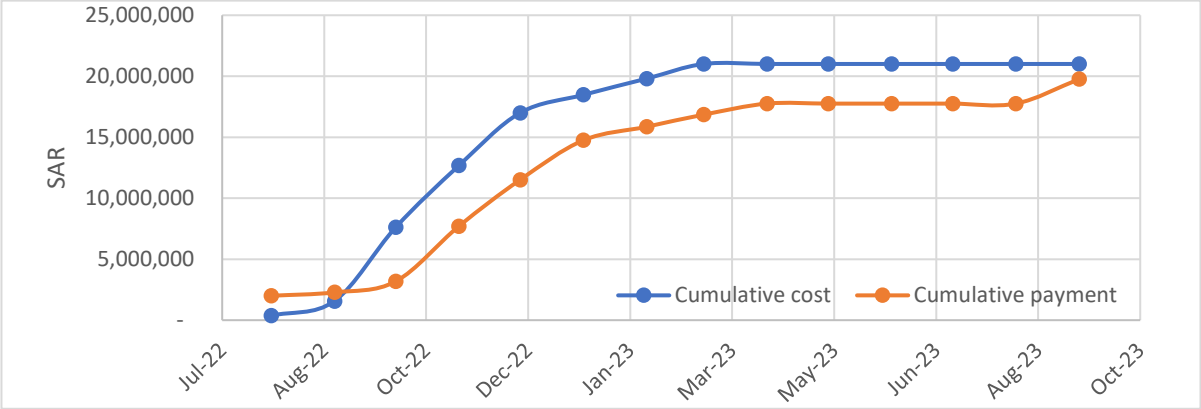

Figure 42 Mitigated Cumulative Cost and Payment Cash Flows for Oct. Underestimation (Amended Payment Terms)

As discussed in this section, the impact of the mitigation methods on the underestimation risk was summarized in Table 15 below.

Table 15 summary for mitigation methods for Underestimation Risk

Mitigation for Underestimation				
Case	**Cumulative Negative Cash Flow**	**% of Improvement**	**Sum of Negative Payment**	**% of Improvement**
Baseline	(38,408,291.91)		(11,070,693.27)	
Loan in Oct.	(19,508,244.19)	49.2%	(7,750,686.91)	30.0%
Equity in Oct.	(19,408,291.91)	49.5%	(7,737,359.94)	30.1%
Amending the Payment Terms	(26,719,594.36)	30.4%	(7,548,220.30)	31.8%

4.3.2 Mitigation Methods for Delayed Payment

The contract encountered delays for the December payment and got paid in the following two months, the total sum of the negative periodic payment would reach the lowest value, which would be 14,387,976 SAR, which is 72% of the contract value and the cumulative negative cash flow reached value of 41,629,172 SAR leading to 17% less than the baseline cumulative negative payment.

The contractor adopted three mitigation scenarios which were taking loans from the bank, changing payment terms by offering deduction to the early payment or investing from the contractor's equity. Therefore, this section discussed impact of these mitigation methods on the negative cash flow, how it affected the total negative payments and cumulative negative cash flow developed due to the delayed payment during the construction phase.

Loans for Delayed Payment

The contractor applied various scenarios for the loan taken from the bank by changing the months that the contractor received the loan in; and table 16 was developed according to these scenarios.

Table 16 Loan Scenarios to Mitigate Delayed Payment

Bank Loan Received	Updated Negative Cumulative	%	Updated Negative Periodic	%
Base for Delay	(41,629,172.46)	208%	(14,387,976.73)	72%
September 2022	(24,769,105.65)	124%	(11,747,964.00)	59%
October 2022	(22,729,124.73)	114%	(11,407,967.18)	57%
November 2022	(25,029,140.64)	125%	(11,067,970.36)	55%
December 2022	(27,669,153.37)	138%	(10,727,973.54)	54%
January 2023	(30,649,162.91)	153%	(14,727,973.54)	74%

In light of the above table, it can be concluded that the contractor shall take loan in October in order to achieve the lowest value for the total net negative payment of the project and successfully mitigate the negative cash flow.

Since it was concluded that the bank loan shall be taken in December the author developed the below payment schedule, Figure 43, and graphs in order to represent the impact of such mitigation method.

Accordingly, the loan would reduce the total sum of the negative payment from 14,387.977 SAR to 11,407,967 SAR with total improvement 21% from the value of the total negative payments of the delayed cash flow scenario and the cumulative negative cash flow was improved by 45% by changing from 41,629,172 SAR to 22,729,125 SAR.

As illustrated in Figure 44 and 45, the gap between the cumulative payment and cumulative cost was significantly reduced compared to the baseline schedule after receiving the loan. However, the contractor still incurred negative cash flow throughout the construction phase of the project.

Loan														
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Bank Payment			4,000,000											
Bank Costs			-	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)
Updated Cumulative Cost	371,252	1,563,921	6,596,547	12,004,504	16,668,310	18,487,188	20,154,833	21,699,984	22,039,981	22,379,978	22,719,975	23,059,971	23,399,968	23,739,965
Updated Cumulative Payment	2,000,000	2,000,000	6,297,001	7,251,137	7,251,137	13,318,556	18,790,653	19,973,758	21,035,877	22,000,000	22,000,000	22,000,000	22,000,000	24,000,000
Updated Cumulative Net	1,628,748	436,079	(299,545)	(4,753,368)	(9,417,173)	(5,168,632)	(1,364,180)	(1,726,226)	(1,004,104)	(379,978)	(719,975)	(1,059,971)	(1,399,968)	260,035
Updated Periodic Net	1,628,748	(1,192,669)	(735,625)	(4,453,822)	(4,663,805)	4,248,541	3,804,452	(362,046)	722,122	624,127	(339,997)	(339,997)	(339,997)	1,660,003
Cumulative Negative	(22,729,125)	114%												
Sum of Negative Payment	(11,407,967)	57%												

Figure 43 Updated Payment Schedule for Loan against Dec. Delayed Payment

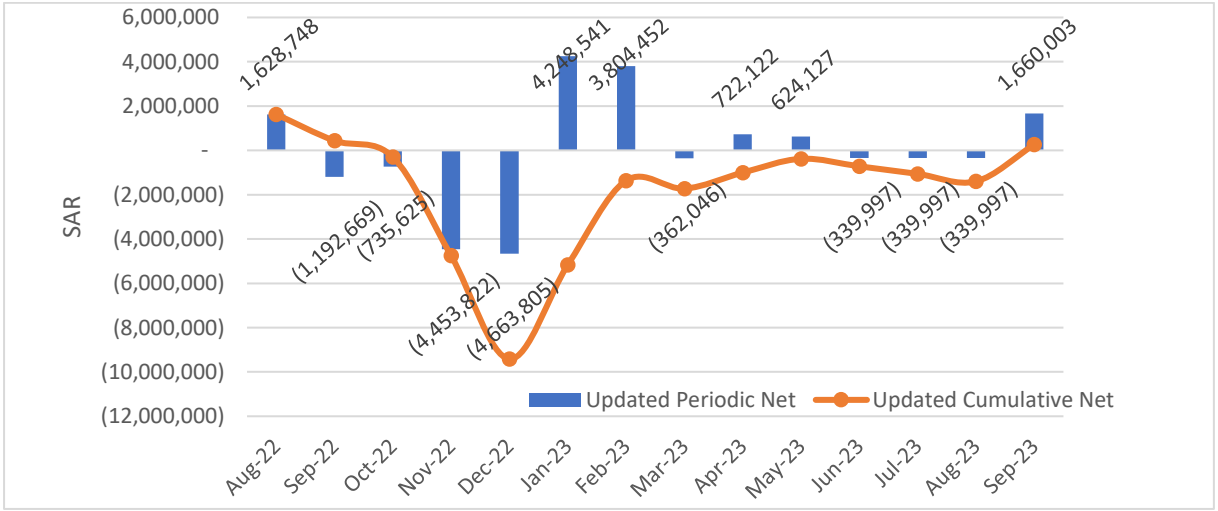

Figure 44 Mitigated Net Periodic vs Net Cumulative for Dec. Delayed Payment (Loan)

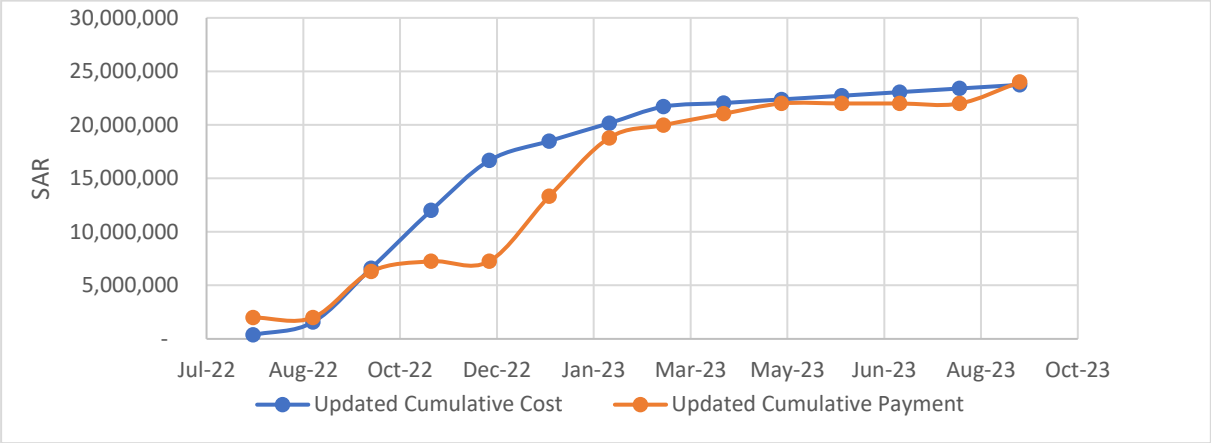

Figure 45 Mitigated Cumulative Cost and Payment Cash Flows for Dec. Delayed Payment (Loan)

Equity for the Delayed Payment

This section comprehended the impact of investing a portion of the contractor's equity in order to mitigate the negative cash flow caused by the October payment delay. The value of the invested equity shall not exceed 20% of the contract value. The invested equity was repaid in 12 equal monthly instalments with value of 333,333 SAR.

In light of the loan scenario, the contractor developed a payment schedule, Figure 46, where the equity was invested in December in order to determine the difference between investing equity and bank loans for the same risk.

Accordingly, the equity investment would reduce the total sum of the net negative payment from 14,387.977 SAR to 11,387,977 SAR with total improvement 21% from the value of the total negative payments of the delayed cash flow scenario. On other hand, the cumulative negative cash flow was improved from 41,629,172 SAR to 22,629,172 SAR with 46% improvement. As illustrated in Figure 47 and 48, the gap between the cumulative payment and cumulative cost was significantly reduced compared to the baseline schedule after receiving the equity. However, the contractor still incurred negative cash flow throughout the construction phase of the project.

Equity														
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Equity Investiment			4,000,000											
Equity Cost				333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333
Updated Cumulative Cost	371,252	1,563,921	6,596,547	11,997,841	16,654,983	18,467,197	20,128,179	21,666,667	22,000,000	22,333,333	22,666,667	23,000,000	23,333,333	23,666,667
Updated Cumulative Payment	2,000,000	2,000,000	6,297,001	7,251,137	7,251,137	13,318,556	18,790,653	19,973,758	21,035,877	22,000,000	22,000,000	22,000,000	22,000,000	24,000,000
Updated Cumulative Net	1,628,748	436,079	(299,545)	(4,746,704)	(9,403,846)	(5,148,642)	(1,337,526)	(1,692,909)	(964,123)	(333,333)	(666,667)	(1,000,000)	(1,333,333)	333,333
Updated Periodic Net	1,628,748	(1,192,669)	(735,625)	(4,447,159)	(4,657,142)	4,255,204	3,811,116	(355,382)	728,785	630,790	(333,333)	(333,333)	(333,333)	1,666,667
Cumulative Negative	(22,629,172)	113%												
Sum of Negative Payment	(11,387,977)	57%												

Figure 46 Updated Payment Schedule for Equity against Dec. Delayed Payment

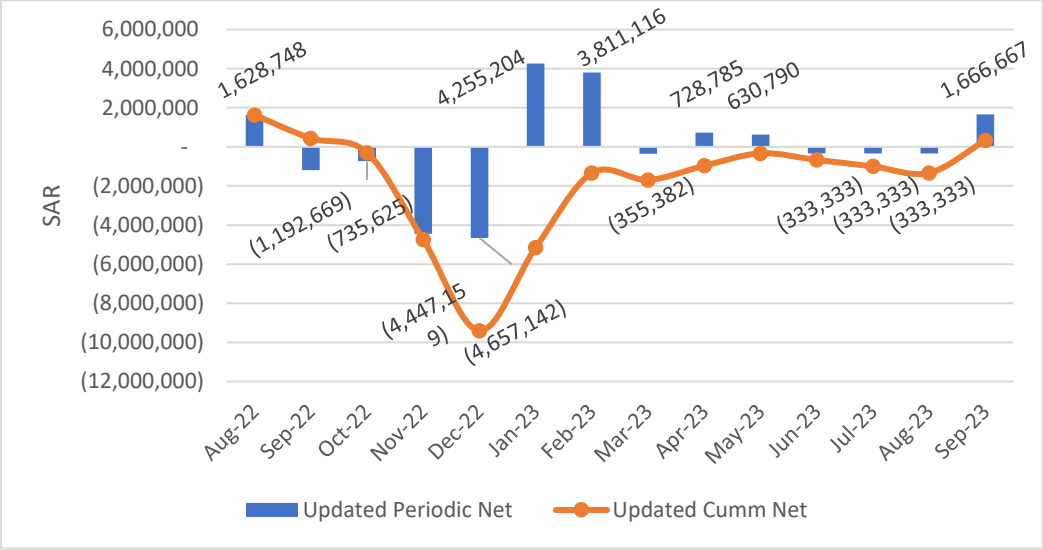

Figure 47 Mitigated Net Periodic vs Net Cumulative for Dec. Delayed Payment (October Equity)

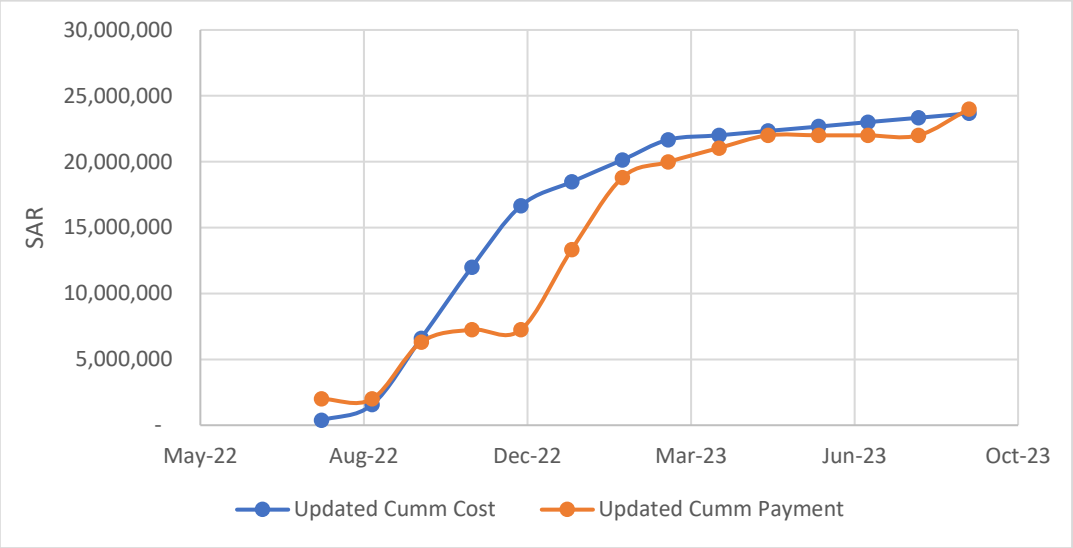

Figure 48 Mitigated Cumulative Cost and Payment Cash Flows for Dec. Delayed Payment (October Equity)

Amending the Payment Terms for Delayed Payment

The author developed payment schedule, Figure 49, where the contractor amended the payment terms after the occurrence of the delayed payment and started to receive the payment within 30 days from the completion date of work starting from January 2023; accordingly, the contractor was paid on monthly basis with total deduction of 5% of the value of the invoiced work. However, the advance payment and retention shall have remained the same value which was 2,000,000 SAR each, as the contract value was not amended.

Accordingly, amending payment terms would increase the total sum of the negative payment from 14,387.977 SAR to 14,575,346 SAR with 1.3% from the value of the total negative payments of the delayed cash flow scenario. On other hand, the cumulative negative cash flow was improved from 41,629,172 SAR to 37,547,938 SAR with 9.8% improvement. As illustrated in Figure 50 and 51, the gap between the cumulative payment and cumulative cost was slightly reduced compared to the baseline schedule after amending the payment terms after the occurrence of the delayed payment and the contractor still incurred negative cash flow throughout the construction phase of the project with lose of profit 3% of the total value of the contract value.

Deduction for 30 days	5%

Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23
Periodic cost	371,252	1,192,669	5,032,626	5,067,961	4,323,809	1,478,882	1,327,648	1,205,154						
Cumulative cost	371,252	1,563,921	6,596,547	11,664,507	15,988,316	17,467,197	18,794,846	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
Periodic Payment	2,000,000		297,001.25	954,135.36		9,056,877.34	3,122,211.49	995,736.26	903,865.63	-	-	-	-	2,000,000
Cumulative payment	2,000,000	2,000,000	2,297,001	3,251,137	3,251,137	12,308,014	15,430,225	16,425,962	17,329,827	17,329,827	17,329,827	17,329,827	17,329,827	19,329,827
Updated Net Cumulative	1,628,748	436,079	(4,299,545)	(8,413,371)	(12,737,179)	(5,159,184)	(3,364,620)	(3,574,038)	(2,670,173)	(2,670,173)	(2,670,173)	(2,670,173)	(2,670,173)	(670,173)
Updated Periodic Net	1,628,748	(1,192,669)	(4,735,625)	(4,113,825)	(4,323,809)	7,577,996	1,794,563	(209,418)	903,866	-	-	-	-	2,000,000
Cumulative negative	(37,547,938)	188%												
Sum of Negative Payment	(14,575,346)	73%												

Figure 49 Updated Payment Schedule for Amended Payment against Dec. Delayed Payment

.

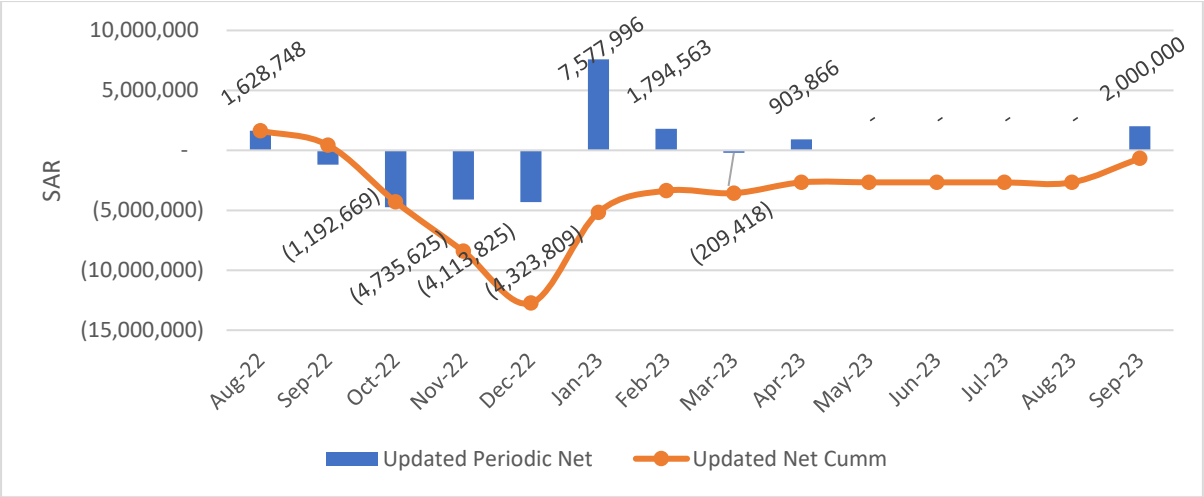

Figure 50 Mitigated Net Periodic vs Net Cumulative for Dec. Delayed Payment (Amended Payment Terms)

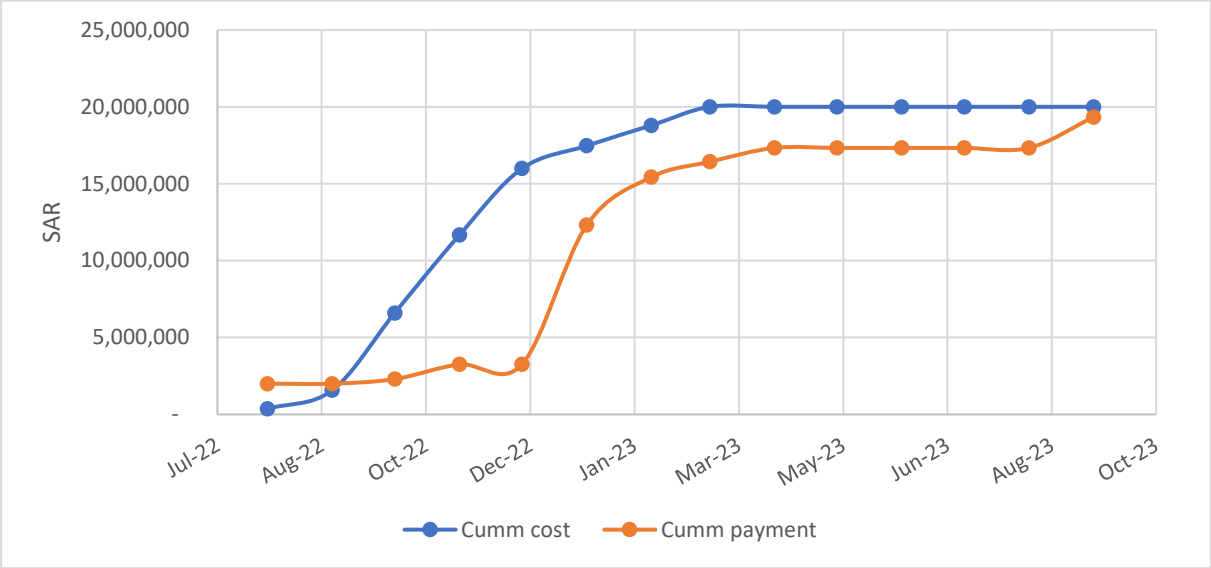

Figure 51 Mitigated Cumulative Cost and Payment Cash Flows for Dec. Delayed Payment (Amended Payment Terms)

As discussed in this section, the impact of the mitigation methods on the delayed payment risk was summarized in Table 17 below.

Table 17 summary for mitigation methods for Delayed Payment Risk

Mitigation for Delayed Payment				
Case	**Cumulative Negative Cash Flow**	**% of Improvement**	**Sum of Negative Payment**	**% of Improvement**
Baseline	(41,629,172.46)		(14,387,976.73)	
Loan in October	(22,729,124.73)	45%	(11,407,967.18)	21%
Equity in October	(22,629,172.46)	46%	(11,387,976.73)	21%
Amending the Payment Terms	(37,547,937.62)	9.8%	(14,575,345.69)	-1.3%

4.3.3 Mitigation for Poor Planning

Due to the poor management from the contractor side, the project was delayed, as the contractor had slower performance than the planned one besides the delayed mobilization, the total duration for the construction phase was extended till July 2023 instead of the planned completion date which was March 2023.

The author assumed that neither total value of the project nor the total cost would change due to the prolonged duration leading to change in the negative cash flow and sum of total net negative periodic payment throughout the construction phase of the project. The cumulative negative cash flow was improved by 4% and became 34,187,035 SAR instead of 35,590,021 SAR and the total sum of the negative

payment decreased by the 23% and became 12,694,808 SAR instead of 10,361,876 SAR.

Therefore, the contractor adopted three mitigation scenarios which were taking loans from the bank, changing payment terms by offering deduction to the early payment or investing from the contractor's equity. This section discussed impact of these mitigation methods on the negative cash flow, how it affected the total negative payments and cumulative negative cash flow developed due to the poor planning during the construction phase.

Loans for Poor Planning

The contractor applied various scenarios for the loan taken from the bank by changing the month that the contractor received the loan in; and table 18 was developed according to these scenarios.

Table 18 Loan Scenarios to Mitigate Poor Planning

Bank Loan Received	Updated Negative Cumulative	%	Updated Negative Periodic	%
September 2022	(18,487,065.09)	92%	(13,896,194.99)	69%
October 2022	(16,447,084.18)	82%	(10,754,021.59)	54%
November 2022	(17,095,881.19)	85%	(12,123,202.20)	61%
December 2022	(19,395,897.09)	97%	(14,054,795.53)	70%
January 2023	(19,677,869.09)	98%	(14,054,795.53)	70%
February 2023	(18,065,843.17)	90%	(12,581,612.99)	63%
March 2023	(17,716,608.15)	89%	(10,725,550.97)	54%
April 2023	(20,227,015.68)	101%	(10,769,564.33)	54%
May 2023	(23,207,025.22)	116%	(13,034,805.07)	65%

With reference to the above table, it can be concluded that the contractor shall take loan in October 2022 in order to achieve the lowest value for the total net negative payment of the project and successfully mitigate the negative cash flow.

Since it was concluded that the bank loan shall be taken in October the author developed the below payment schedule, Figure 52, and graphs in order to represent the impact of such mitigation method.

Loan																		
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24
Bank Payment			4,000,000															
Bank Costs			-	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	(339,997)	-	-	-
Updated Cumulative Cost	209,413	1,048,007	4,856,308	7,798,774	8,546,996	9,074,970	10,874,733	14,014,363	17,787,413	19,599,190	21,306,378	23,059,971	23,399,968	23,739,965	24,079,962	24,079,962	24,079,962	24,079,962
Updated Cumulative Payment	2,000,000	2,000,000	6,167,530	6,838,406	9,885,047	11,967,022	12,293,602	12,443,984	13,611,797	15,851,503	18,597,946	19,775,370	20,869,123	22,000,000	22,000,000	22,000,000	22,000,000	24,000,000
Updated Cumulative Net	1,790,587	951,993	1,311,222	(960,368)	1,338,050	2,892,051	1,418,869	(1,570,379)	(4,175,616)	(3,747,687)	(2,708,432)	(3,284,602)	(2,530,845)	(1,739,965)	(2,079,962)	(2,079,962)	(2,079,962)	(79,962)
Updated Periodic Net	1,790,587	(838,594)	359,229	(2,271,590)	2,298,418	1,554,001	(1,473,183)	(2,989,248)	(2,605,238)	427,929	1,039,255	(576,169)	753,756	790,880	(339,997)	-	-	2,000,000
Cumulative Negative	(16,447,084)	82%																
Sum of Negative Payment	(10,754,022)	54%																

Figure 52 Updated Payment Schedule for Loan against Poor Planning

Accordingly, the loan would reduce the total sum of the negative payment from 12,694,808 SAR to 10,754,022 SAR with total improvement 15% from the value of the total negative payments and the cumulative negative cash flow was reduced from 34,187,035 SAR to 16,447,084 SAR with total improvement 52%.

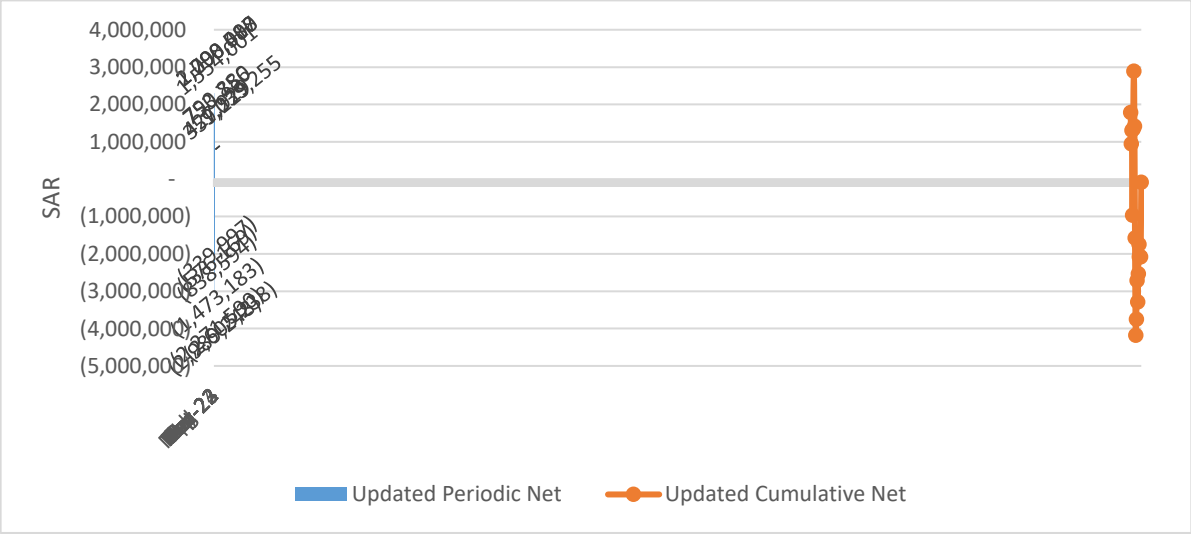

Figure 53 Mitigated Net Periodic vs Net Cumulative for Poor Planning (October Loan)

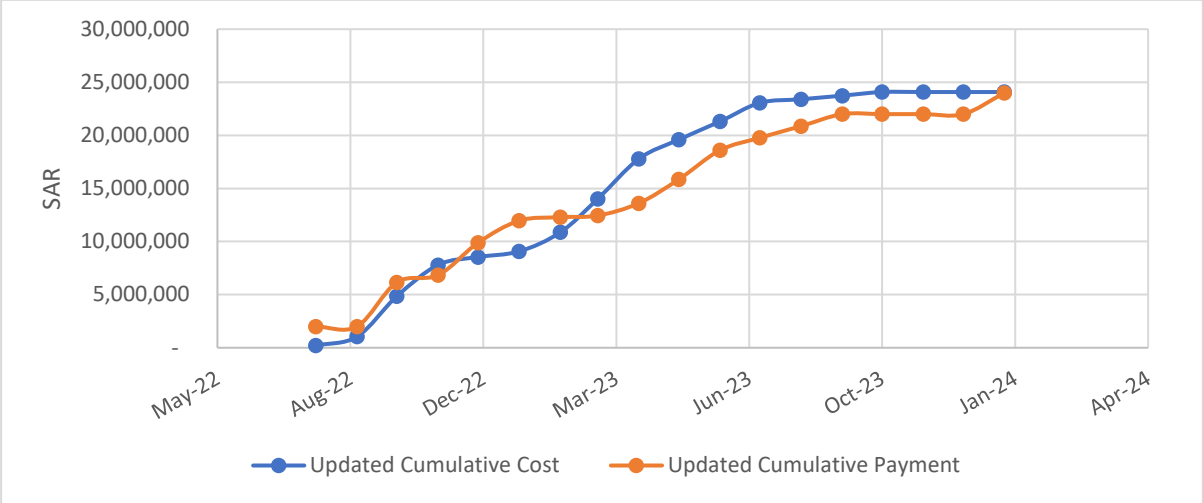

Figure 54 Mitigated Cumulative Cost and Payment Cash Flows for Poor Planning (October Loan)

As illustrated in Figure 53 and 54, the gap between the cumulative payment and cumulative cost was affected by the loan compared to the baseline schedule after receiving the loan. However, the contractor still incurred negative cash flow from March 2023 till the completion of the construction phase of the project.

Equity for Poor Planning

In accordance with the loan scenario, the contractor developed a payment schedule, Figure 55, where the equity was invested in October 2022 in order to determine the difference between investing equity and bank loans for the same risk and having better understanding regarding the impact of investing equity on the negative cash flow.

Accordingly, the equity investment would reduce the total sum of the negative payment from 12,694,808 SAR to 8,455,778 SAR with total improvement 33% from the value of the total negative payments of the delayed cash flow scenario. On other hand, the cumulative negative cash flow was improved from 34,187,035 SAR to 16,207,199 SAR with 53% improvement.

Equity																		
Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24
Equity Investiment			4,000,000															
Equity Cost				333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333	333,333			
Updated Cumulative Cost	209,413	1,048,007	4,856,308	7,792,110	8,533,669	9,054,980	10,848,079	13,981,045	17,747,432	19,552,546	21,253,070	23,000,000	23,333,333	23,666,667	24,000,000	24,000,000	24,000,000	24,000,000
Updated Cumulative Payment	2,000,000	2,000,000	6,167,530	6,838,406	9,885,047	11,967,022	12,293,602	12,443,984	13,611,797	15,851,503	18,597,946	19,775,370	20,869,123	22,000,000	22,000,000	22,000,000	22,000,000	24,000,000
Updated Cumulative Net	1,790,587	951,993	1,311,222	(953,705)	1,351,377	2,912,042	1,445,523	(1,537,061)	(4,135,636)	(3,701,043)	(2,655,124)	(3,224,630)	(2,464,211)	(1,666,667)	(2,000,000)	(2,000,000)	(2,000,000)	-
Updated Periodic Net	1,790,587	(838,594)	359,229	(1,931,593)	2,638,415	1,893,998	(1,133,186)	(2,649,251)	(2,265,241)	767,926	1,379,252	(236,173)	1,093,753	1,130,877	-	-	-	2,000,000
Cumulative Negative	(16,207,199)	81%																
Sum of Negative Payment	(7,122,444)	36%																

Figure 55 Updated Payment Schedule for Equity against Poor Planning

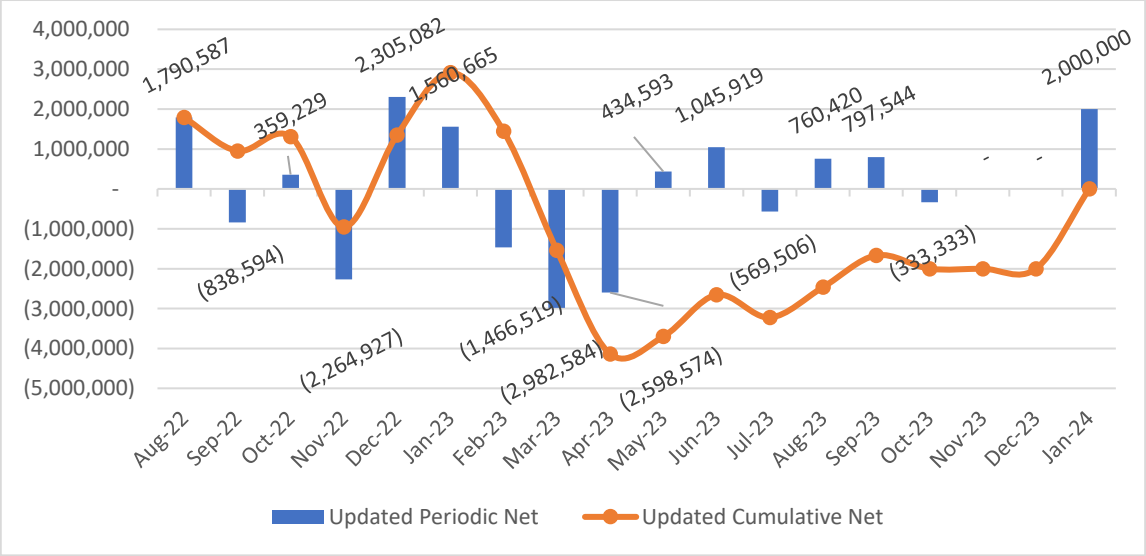

Figure 56 Mitigated Net Periodic vs Net Cumulative for Poor Planning (Oct. Equity)

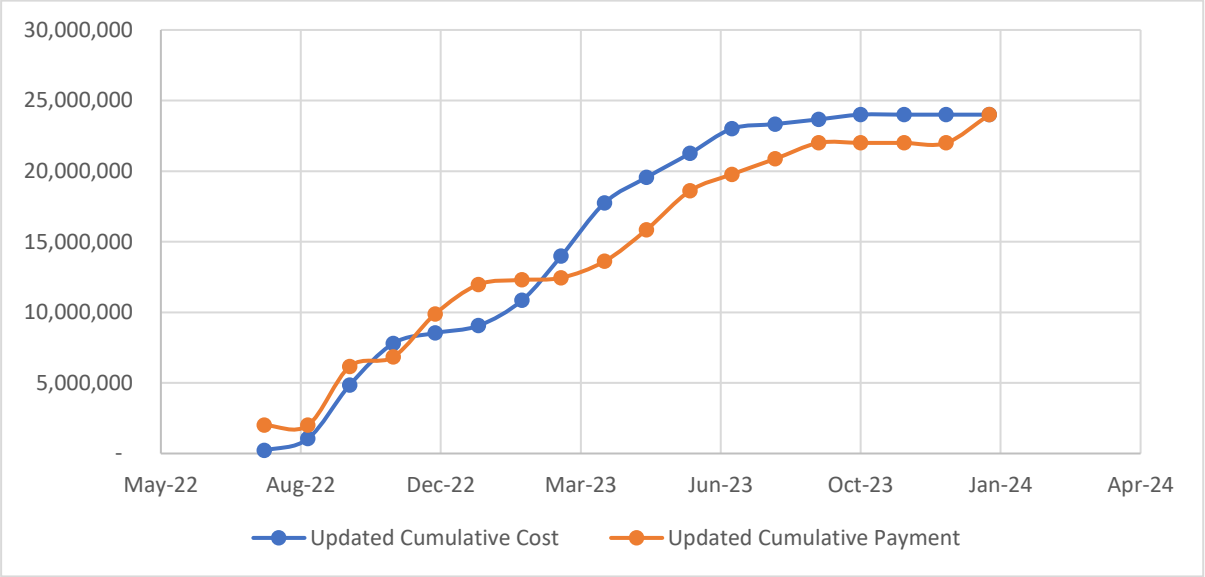

Figure 57 Mitigated Cumulative Cost and Payment Cash Flows for Poor Planning (Oct. Equity)

As illustrated in Figure 56 and 57, the gap between the cumulative payment and cumulative cost was significantly affected by the equity invested compared to the baseline schedule after receiving the loan. The contractor was able to keep the cumulative net cash flow positive for the whole duration of the construction phase except for November 2022, April and May 2023.

Amending the Payment Terms for Poor Planning

The author developed payment schedule, Figure 58, where the contractor received the payment within 30 days from the completion date of work; accordingly, the contractor was paid on monthly basis with total deduction of 5% of the value of the invoiced work. However, the advance payment and retention shall have remained the same value, which was 2,000,000 SAR each, as the contract value was not amended.

Accordingly, amending payment terms would reduce the total sum of the negative net periodic payment from 12,694,808 SAR to 8,463,123 SAR with total improvement 33% from the value of the total negative payments and the cumulative negative cash flow was reduced from 34,187,035 SAR to 19,907,849 SAR with total improvement 42%.

Deduction for 30 days	5%

Months	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24
Periodic cost	209,413	838,594	3,808,301	2,602,469	408,226	187,977	1,459,766	2,799,633	3,433,054	1,471,780	1,367,191	1,413,597						
Cumulative cost	209,413	1,048,007	4,856,308	7,458,777	7,867,003	8,054,980	9,514,746	12,314,379	15,747,432	17,219,212	18,586,403	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
Periodic Payment	2,000,000	157,059.74	670,875.34	3,046,640.91	2,081,974.94	326,580.61	150,381.61	1,167,813.06	2,239,706.02	2,746,443.04	1,177,423.91	1,093,752.94	1,130,877.23	-				2,000,000
Cumulative payment	2,000,000	2,157,060	2,827,935	5,874,576	7,956,551	8,283,132	8,433,513	9,601,326	11,841,032	14,587,475	15,764,899	16,858,652	17,989,529	17,989,529	17,989,529	17,989,529	17,989,529	19,989,529
Updated Net Cumulative	1,790,587	1,109,053	(2,028,373)	(1,584,201)	89,548	228,152	(1,081,233)	(2,713,052)	(3,906,400)	(2,631,737)	(2,821,504)	(3,141,348)	(2,010,471)	(2,010,471)	(2,010,471)	(2,010,471)	(2,010,471)	(10,471)
Updated Periodic Net	1,790,587	(681,534)	(3,137,426)	444,172	1,673,749	138,604	(1,309,385)	(1,631,819)	(1,193,348)	1,274,663	(189,767)	(319,844)	1,130,877	-	-	-	-	2,000,000
Cumulative negative	(19,907,849)	100%																
Sum of Negative Payment	(8,463,123)	42%																

Figure 58 Updated Payment Schedule for Amending Payment Terms against Poor Planning

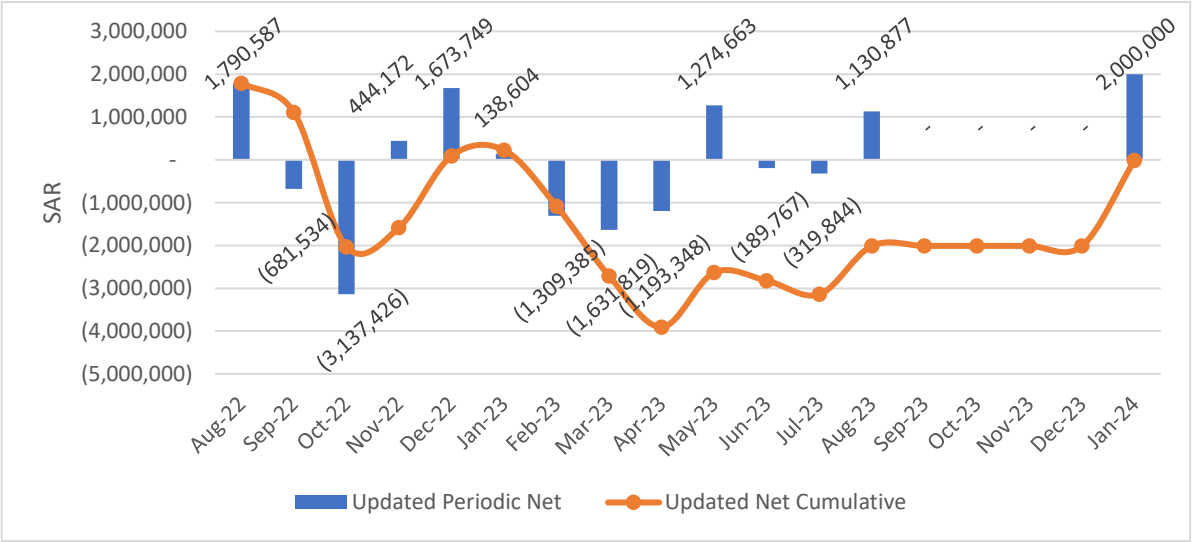

Figure 59 Mitigated Net Periodic vs Net Cumulative for Poor Planning (Amending Payment Terms)

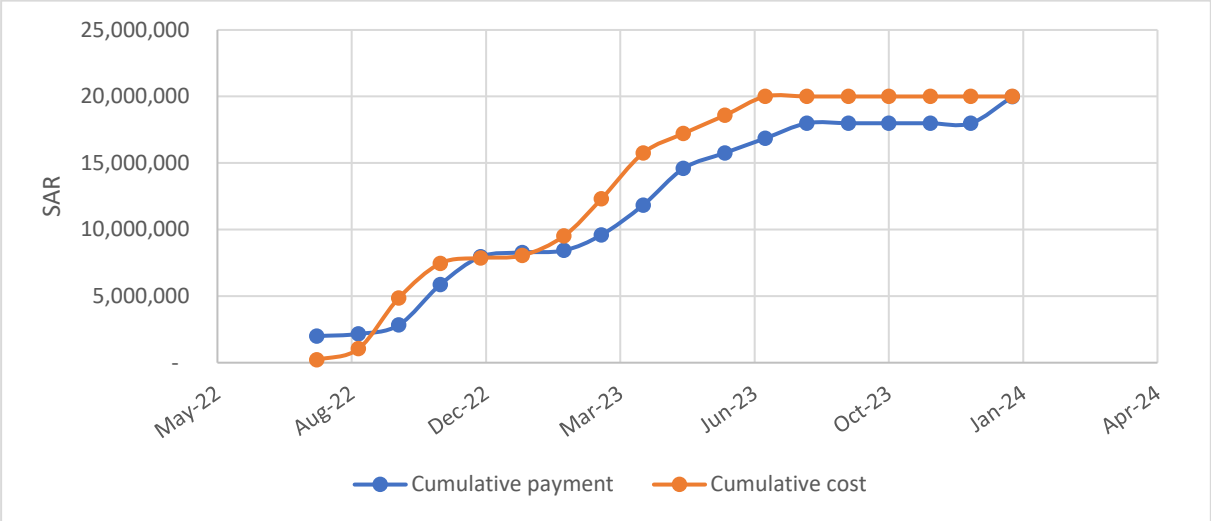

Figure 60 Mitigated Cumulative Cost and Payment Cash Flows for Poor Planning (Amending Payment Terms)

As illustrated in Figure 59 and 60, the gap between the cumulative payment and cumulative cost was affected by amending payment terms compared to the baseline schedule after receiving the loan. However, the contractor still incurred negative cash flow from February 2023 till the completion of the construction phase of the project.

As discussed in this section, the impact of the mitigation methods on the delayed payment risk was summarized in Table 19 below.

Table 19 summary for mitigation methods for Poor Planning Risk

Mitigation for Poor Planning				
Case	**Cumulative Negative Cash Flow**	**% of Improvement**	**Sum of Negative Payment**	**% of Improvement**
Baseline	(34,187,034.77)		(12,694,808.25)	
Loan in October 2022	(16,447,084.18)	52%	(10,754,021.59)	15%
Equity in October 2022	(16,207,198.72)	53%	(8,455,777.51)	33%
Amending the Payment Terms	(19,907,848.86)	42%	(8,463,123.06)	33%

4.4 Analysis

As recommended by Halpin & Senior (2009), an S-curve shall be developed to illustrate the correlation between the contractor's cumulative payment and the contractor's cumulative costs incurred throughout the project. These curves are essential, as the contractor seeks to narrow the disparity between them to ensure that the cumulative payment curve is greater than the cumulative cost curve in order to avoid negative cash flow.

In addition to the aforementioned and in light of Table 13 developed in the previous section, the author used the sum of negative cumulative net cash flow to differentiate between the impacts of risks. The greater the negative value, the greater the risk and the author concluded that delayed payment has the most significant negative impact on net project cash flow and the poor planning has the lowest negative impact on the net cash flow.

Moreover, the author implemented three main mitigation methods on each risk in order to comprehend the impact of these methods against these risks and their efficiency. As a result, the author developed S-curves for mitigations methods against the risk in order to illustrate their impact graphically.

The author developed s-curves for the mitigation methods for the underestimation risks in order to identify the most efficient method to mitigate the underestimation, delayed payment and poor planning risks as shown in Figure 61, 62, 63 respectively.

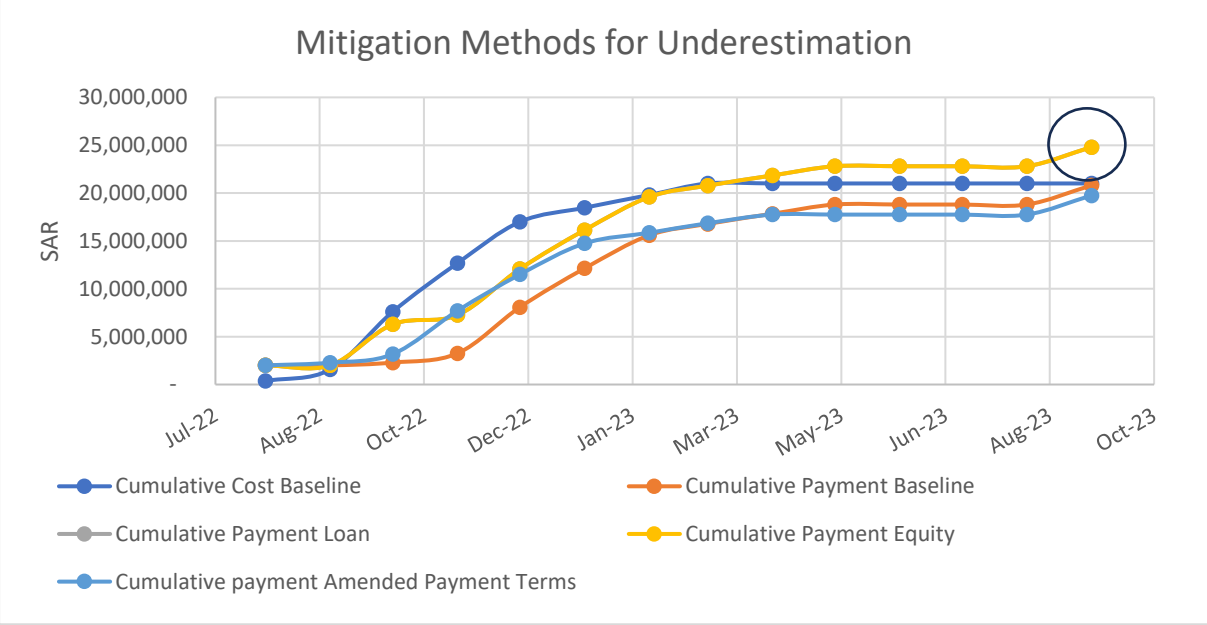

Figure 61 Mitigation Methods for Underestimation

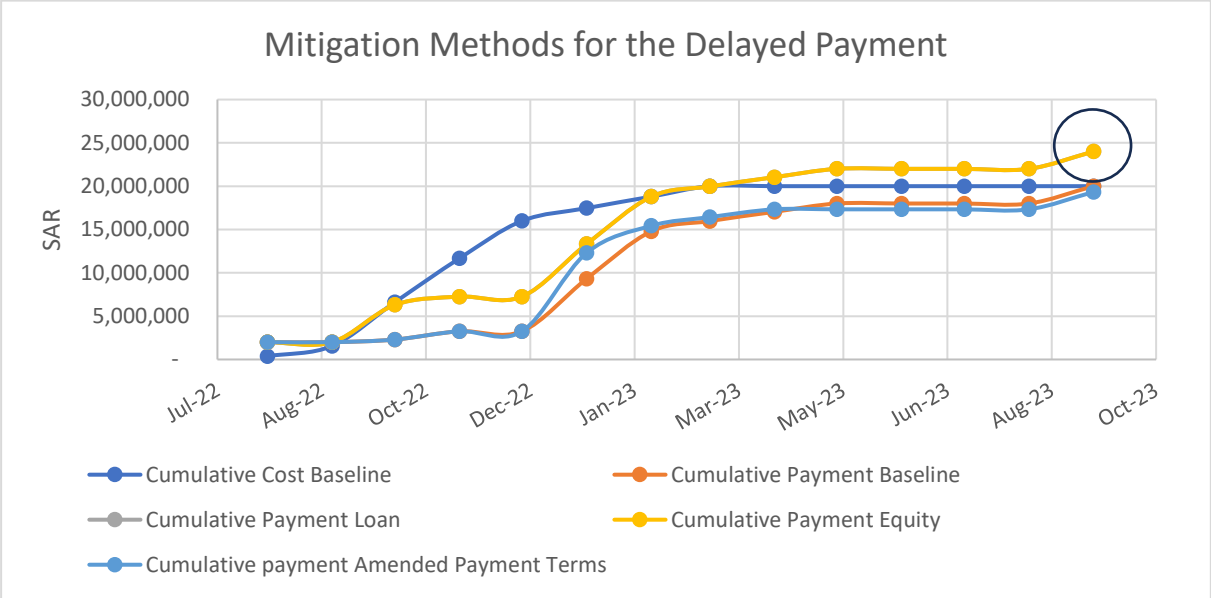

Figure 62 Mitigation Methods for Delayed Payment

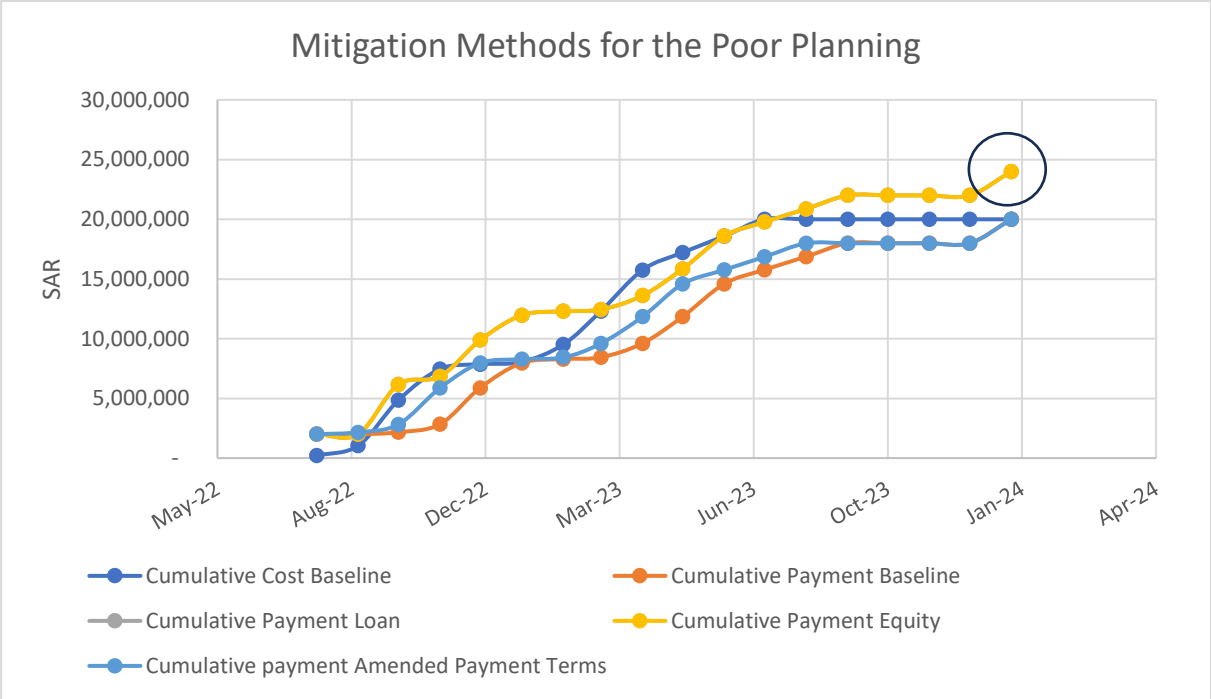

Figure 63 Mitigation Methods for Poor Planning

The contractor should not rely solely on the aforementioned s-curves to determine the most effective mitigation method due to the fact that the loan and loan scenario altered the cumulative cost cash flow due to the contractor's payment of bank interest and equity cost. in addition to the mentioned matter, the cumulative payment cash flow of the loan and equity scenarios are identical; hence, the contractor must combine s-curve methods and tables concluded at the end of each section, tables 15,17&19 to have an adequate comparison.

The limitations of relying solely on S-curves to differentiate between various mitigation scenarios were evident in the loan and equity scenarios. Despite the curves showing an additional 4 million at the end of the project, circled in the figure above, this was not the case. The contractor incurred additional costs in the form of bank payments and equity payback. This highlighted the need for a more comprehensive approach to analysing mitigation scenarios.

So as to determine the most effective mitigation method, it is necessary for the contractor to integrate the curves and table developed at the end of each section and compare the total cumulative negative cash flow. The author of the study was able to ascertain the ideal timing for the contractor to receive a loan or invest part of the equity in order to achieve the greatest reduction in negative cash flow. Typically, contractors invest part of the equity or receive a loan at the peak of construction works to finance site operations. However, the case study presented showed that the contractor should receive the loan or invest the equity once the cumulative net cash flow has begun to decline, which occurred in October in this case.

In order to address negative cash flow, contractors should implement their mitigation strategies during the period when the net cumulative cash flow begins to show a negative value.

5 Conclusion

There is no denying the fact that negative cash flow is an integral and significant component of any construction project. The contractor is obliged to cover the expenditures needed to achieve the project works without receiving adequate payment from the employer to compensate for the cost of the current works being achieved on site, which results in a negative cash flow.

As discussed earlier in this review of the relevant literature, many researchers investigated the cash flow of construction projects as well as their management methods, the risks that could jeopardise cash flow management and the sustainability of the project, and the measures that could be used to mitigate these risks. As a result, the literature analysis concluded that various management strategies might be used without emphasising the practical impact those methods would have on the project's cash flow. In addition to the cash flow management measures, the literature review revealed numerous risks that could put the construction project at risk. It associated these risks with the project's stakeholders, such as the consultant, the contractor, and the client.

On the other hand, the analysis of the relevant literature revealed that various researchers had independently studied project management strategies, risk management approaches, or risk identification; consequently, this paper demonstrated the correlation between these aspects. The construction business is known for its volatility and instability. Hence, this strategy was chosen to account for those factors. As a result, the author attempted to establish a connection between these subjects by drawing attention to their impact on negative cash flow and by responding to the research questions listed below.

Q1) What are the causes of the negative cash flow?

After doing a comprehensive literature analysis of earlier papers published on the topic of risk identification, the author was able to classify the risks in accordance with the element to which each risk is attributed. The literature review allowed the author to provide a satisfactory response to the aforementioned question.

Many of the risk factors are related to the payment terms and their frequencies that are attributable to the contractor and the clients. Others, in contrast, are attributable to the suppliers and subcontractors, while others are attributable to the government-imposed restrictions.

As a result, this list of the main risks that various academics have mentioned and that directly affect cash flow. These risks are broken out as follows:

- Delayed Payment
- Change order
- Delayed procurement
- Change in the scope of work
- Inflation
- Change in the interest rate
- Underestimation during tendering
- Change in a sequence of the activities
- Site condition
- Poor planning

Simply acknowledging the risks was insufficient to comprehend and evaluate the effects that these risks had. Considering this, the author decided to conduct a survey to have better comprehension regarding these risks, their likelihood, and the impact they pose.

Q2) How often does the contractor face these events?

As a result of the gap that the author discovered after conducting a literature review, the author made the decision to categorise the risks discussed above according to the possibility of each risk occurring and the impact each risk would have on the cash flow of the construction project. As a consequence of this, the author was required to carry out a survey in order to gain an understanding of the correlation that exists between the risks discussed previously and the negative cash flow, as well as the influence that these risks have on the cash flow.

The survey respondents hailed from different regions, including Egypt, Germany, Saudi Arabia, India, and other countries. Despite their diverse backgrounds, they unanimously acknowledged that prolonged and unexpected negative cash flow is a crucial matter that demands prompt attention. Accordingly, the survey was conducted

to provide a summary of the contributions made by construction experts who dealt directly with negative cash flow, and these professionals corroborated the severity of the risks that were determined from the literature research. It was requested of the respondents that they select only the three dangers from the previously listed hazards that had the highest likelihood in comparison to the other risks, and they were given the opportunity to add any other risk if they considered that it has a higher likelihood in comparison to the ten risks that were previously mentioned.

The result of that question was that the most prevalent risks were:

- delayed payment,
- underestimating during tendering, and
- poor planning.

Such a question was not enough to comprehend the impact of these risks and verify their likelihood; accordingly, the respondents were asked to evaluate the ten risks based on how likely they were and how severe their impact would be, and these questions pertained to the frequency and severity of each of the risks. As a result, the survey confirmed that the three risks that respondents believed were the most prevalent had the most significant potential for harm and were the most likely to occur during the construction project.

Q3) How to predict negative cash flow?

This question was answered throughout the paper. The literature review introduced the reader to the cost management strategies which were cash balance module and the cumulative S-curve. These methods were sufficient to describe the cash flow performance for the costs incurred by the contractor and the payments paid the client. As a result of the literature review, the author concluded that the S-curve was more appropriate for representing negative cash flow than the cash balance module, which separates costs into multiple modules, making it difficult for the contractor to identify negative cash flow. In addition to the preceding point and with reference to (Halpin & Senior, 2009), the S-curve is the most common method for monitoring the cash performance of a project because it represents the cash flow through two primary curves, namely:

- Cost curve representing expenditures incurred by the contractor.
- Payment curve representing payments received by the contractor.

The space between these curves represents the cumulative net curve, and when the payment curve falls below the expense curve, the cumulative net curve has a negative value.

In addition to the literature review, survey respondents indicated that cash forecasting for the project is a vital tool to predict the negative cash flow and facilitates the mitigation process; therefore, the author conducted the S-curve method to predict the negative cash flow for the case study, and it was an adequate tool to predict the negative cash flow through the net cumulative curve developed by the differences between cumulative payments and cost.

Q4) How do impacts vary based on the phases of the project life cycle?

The answer of this question is contained in the literature review and case study. The literature review and introduction divided the project life cycle into six discrete phases, each with its objectives and characteristics. Initially, the owner must make several pre-project decisions, followed by the planning and design of the project. Following the contractor's selection, the contractor mobilises to conduct field operations. Fieldwork, which the general populace typically refers to as "construction," can be viewed as a distinct phase. Since these tasks are distinct from the installation work, we separate them into a concluding phase. Due to the fact that the majority of the project's time and expenses are incurred during the construction phase, the impact of the risk is more significant during this phase than in any other. As a result, the paper addressed the impact of these risks during the construction phase as well as their mitigation strategies. In addition to the conclusion drawn from the literature review, the case study demonstrated the effects of the risks throughout the construction phase. Based on the risk implementation scenarios developed by the author in the case study section, it was evident that the impact of the risk varied over the course of the construction phase.

Therefore, it can be concluded that the underestimation during tender has the most significant negative influence in the month in which the net cumulative cash flow turns negative. For the delayed payment scenarios, the author concluded that the delayed payment has the most crucial impact on cash flow when the value of the delayed payment is one of the highest-value payments, as its delay causes a sudden drop in the cumulative net cash flow, which may result in an unexpected negative

cash flow. Poor planning, on the other hand, may not have a significant impact on the negative cash flow. However, it does cause delays in the projection and unanticipated disturbances in the project's cash flow.

Q5) How to mitigate or eliminate the risks of the negative cash flow?

The conducted survey and the case study led to the conclusion that negative cash flow can be mitigated; nevertheless, completely eliminating it is a nearly impossible goal to achieve. Eliminating the negative cash flow demands a significant investment throughout the course of the project. Neither the client nor the contractor is willing to make such an investment from their own equity or outside financial entities for the sole purpose of eliminating the cash flow, as such a goal will add financial burdens on the contractor due to the interest on the loans or the consumption of the company's equity.

On the other hand, the contractor's overarching objective is to minimise the value of the cumulative negative cash flow while simultaneously working towards mitigating the negative cash flow. The author came to the conclusion, based on the case study that was carried out, that investing a portion of the equity would be the most effective approach to mitigate the negative cash flow. Nevertheless, such an approach may only seem possible to some companies, as it requires a higher contingency margin or the availability of liquid money simultaneously when the risk occurs. However, bank loans are the most realistic strategy for mitigating the negative cash flow. Moreover, the loan scenario is attributable to the local regulations and the interest rate provided by the banks and financial institutions, as shown in Table 20 below, which illustrates the impact of the interest rates of three different countries on the net cumulative cash flow, namely Saudi Arabia, Egypt, and Finland, with interest rates of 3.67 percent, 17.6 percent, and 4.7 percent, respectively.

Table 20 Impact of Interest Rate Scenarios

Impact of Interest Rate on Loan Scenario				
Country (Rate)	Cumulative Negative Cash Flow	% of Improvement	Sum of Negative Payment	% of Improvement
Baseline	(34,187,034.77)		(12,694,808.25)	
Saud Arabia (3.67%)	(16,447,084.18)	51.9%	(10,754,021.59)	15.3%
Egypt (17.6%)	(17,381,720.58)	49%	(10,883,832.20)	14.3%
Finland (4.76%)	(16,518,844.21)	51.7%	(10,763,988.26)	15.2%

In the event that the contractor is unable to invest a portion of the equity or obtain a loan, amending the payment term by reducing the payment duration can improve the negative cash flow with a level of efficiency very close to that of the loan and equity in underestimation and poor planning case, making it a feasible and desirable approach in the event that the contractor does not prefer bank loans, which can lead to additional financial liabilities such as monthly interest. Since the impact of the risk varies throughout the construction phase, so does the mitigation. The contractor is encouraged to use the mitigation approach in the month when the net cumulative cash flow goes negative to mitigate the effect of underestimation, delayed payment or poor planning.

The methodology employed in this study proved sufficient in addressing the research questions and effectively demonstrated the correlation between the three predominant risks, negative cash flow, and the impact of each mitigation strategy. However, further research is required to examine alternative approaches to mitigate the issue, including utilizing various mitigation methods such as obtaining loans and investing a portion of the contractor's equity throughout the construction period, rescheduling specific activities to enhance payment cash flow by completing them earlier than anticipated, and unbalancing bids, in which contractors offset the costs of bid items to receive more payment in the early stages of construction, commonly known as front-end loading.

Furthermore, the author assumed that the company analysed was a small-scale company, which limits the practicality of other mitigation methods. Therefore, further research is needed to explore the applicability of these methods across different scales. Overall, this study provides valuable insights into mitigating risks and improving cash flow in the construction industry. According to the study, implementing mitigation measures in the initial stages of negative cash flow would have a greater impact compared to using them during the peak of work, which is the common practice today.

Contractors can avoid negative cash flow by anticipating risks during planning and establishing mitigation plans. This management style gives them a competitive edge during bidding and helps avoid unexpected cash flow issues.

Declaration of Authorship

I hereby declare that the attached Master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

Berlin, 07/07/2023
Location, Date

Hany Hawash
Signature of the student

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Appendix

Appendix A Distributed Survey

Main Causes of the Negative Cash Flow in the Construction Field

Thank you for taking the time to participate in this survey. The conducted survey aims to identify the main causes of the unexpected and the prolonged negative cash flow in the construction field. The survey aims to identify the risks jeopardising the completion of the construction project by prolonging the negative cash flow. Your participation is critical to help us understand the challenges faced by the industry and develop strategies to mitigate the impact of negative cash flow.

* Indicates required question

1. Years of work experience in the construction field *

Mark only one oval.

- ◯ 0-2 years
- ◯ 2-5 years
- ◯ 5-10 years
- ◯ more than 10 years

2. Your role in the construction field

Mark only one oval.

- ◯ Site Engineer
- ◯ Cost Control
- ◯ Contract Engineer
- ◯ Planner
- ◯ Project Engineer
- ◯ Project Manager
- ◯ Other: _____

3. What is your highest level of education?

Mark only one oval.

- ◯ College (Technical school - Business School - Etc.)
- ◯ Bachelor
- ◯ Master's Degree
- ◯ PhD
- ◯ Other: _____

4. Which country are you currently working in and/or where have you worked in the past? (Name all countries that apply) *

_____

5. In your work, have you encountered projects that experience(d) an unexpected and prolonged negative cash flow? *

Mark only one oval.

- ◯ Yes
- ◯ No

6. Do you consider unexpected and prolonged negative cash flow of the construction project a critical issue? *

Mark only one oval.

- ◯ yes
- ◯ no

7. In your experience, what are the top three risks that contribute to unexpected and prolonged negative cash flow in construction projects *

Check all that apply.

- [ ] Delayed Payment
- [ ] Change Orders
- [ ] Delayed Procurement
- [ ] Change in the Scope of Work
- [ ] Inflation
- [ ] Change in the interest rate
- [ ] Underestimation during Tendering
- [ ] Change in a sequence of the activities
- [ ] Site Condition
- [ ] Poor Planning
- [ ] Other: _____

8. In your experience, what is the likelihood of the below mentioned risks. (0 = never, 4 = Very likely) *

Mark only one oval per row.

	0	1	2	3	4
Delayed payment	◯	◯	◯	◯	◯
Change orders	◯	◯	◯	◯	◯
Delayed procurement	◯	◯	◯	◯	◯
Change in the scope of work	◯	◯	◯	◯	◯
Inflation	◯	◯	◯	◯	◯
Change in the interest rate	◯	◯	◯	◯	◯
Underestimation during tendering	◯	◯	◯	◯	◯
Change in a sequence of the activities	◯	◯	◯	◯	◯
Site condition	◯	◯	◯	◯	◯
Poor planning	◯	◯	◯	◯	◯
The other that you chose above	◯	◯	◯	◯	◯

9. In your experience, what is the Impact of the below mentioned risks *

Mark only one oval per row.

	Low	Moderate	High	Extreme
Delayed Payment	◯	◯	◯	◯
Change Orders	◯	◯	◯	◯
Delayed procurement	◯	◯	◯	◯
Change in the scope of work	◯	◯	◯	◯
Inflation	◯	◯	◯	◯
Change in the interest rate	◯	◯	◯	◯
Underestimation during tendering	◯	◯	◯	◯
Change in a sequence of the activities	◯	◯	◯	◯
Site condition	◯	◯	◯	◯
Poor planning	◯	◯	◯	◯
The other that you chose above	◯	◯	◯	◯

10. Taking into account your previous answers, what options does a company have to finance negative cash flow?

11. What are the methods used by your company/s to optimize the cash flow?

12. Do you believe that the current industry standards and best practices effectively address the risks of negative cash flow?

Mark only one oval.

- ◯ Yes
- ◯ No

13. The reasons behind your previous answer

14. In your experience, Do you think we can avoid unexpected negative cash flow, and if we cannot what is the maximum percentage of negative cash flow out of the total value of the project that can be reached without risking the completion of the project? *

Check all that apply.

- [ ] We can avoid negative cash flow
- [ ] 0-5%
- [ ] 5-10%
- [ ] 10-20%
- [ ] 20-30%
- [ ] others

15. In your experience, which scale of the construction company is at extreme or high risk when it faces unexpected and prolonged negative cash flow?

Check all that apply.

- [ ] Large scale companies
- [ ] Medium scale companies
- [ ] Small scale companies
- [ ] it does not matter

16. Do you have any additional comments or suggestions regarding negative cash flow in the construction industry?