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Web- Based Application for Activity-Based Construction Cost Control in Selected Building Projects in Addis Ababa

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Web- Based Application for Activity-Based Construction Cost Control in Selected Building Projects in Addis Ababa

DECLARATION

I, the undersigned, declare that this thesis work titled "**Web- Based application for Activity-Based Construction Cost Control in Selected Building Projects in Addis Ababa.**" is my original work and it has not been presented for a degree in any other university. All sources of materials used for the thesis have been duly acknowledged.

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The undersigned have examined the thesis entitled **'Web- Based application for Activity-Based Construction Cost Control in Selected Building Projects in Addis Ababa.'** presented by **Hanna H/micheal**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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ABSTRACT

Managing cost is the most important aspect in a construction project as it is an integral and sensitive part of a construction. The activities of contractors, subcontractors, and suppliers are dependent on the consistency of cash flow management of a construction project as it helps in determining how much money is profited after a project completion. If not, it can induce financial constraint or may lead to subsequent claims. However, in Ethiopian Construction Industry, the cost estimation method is usually not linked to the cost management and control mechanisms. In addition the current practice does not offer insight how to value projects or predict price for future bids. Furthermore, it is limited in supporting decision-making and performance control during construction. Current construction projects are also characterized by cost overruns and delays due to inefficient cost controlling processes besides other factors. This study develops a web-based Activity-Based Cost Controlling System by recording actual costs of onsite activities, analyzing and comparing it with budgeted cost, throughout a construction project life cycle to improve the project cost performance. The system uses a centralized database system to store actual cost information collected for each activity using cost codes (of which many activities in building construction share, the system records the daily executed quantities, the material, labor, equipment, and subcontract costs of each activity and analyzes to calculate the direct costs). A backend program is developed using PHP (Hypertext Preprocessor) *that integrates the cost information and the tender price (unit price) of each activity to compare it with the actual cost performance and finally provide performance reports that are automated for control of cost. The web-based application is tested using data from three building projects from different contractors and was found to be close to actual cost. Aside from creating performance reports, the web-based application can provide data on the activities' start and finish dates, and cost information for activities including labor productivity and composition. The result of the study has shown that this web-based application facilitates automation, control, and follow-up of the cost controlling process for contractors.*

Keywords: Web-based Application; Activity-Based Cost Control; Cost Codes; Cost Performance Reports

LIST OF ABBREVIATIONS

ABC:	Activity Based Costing
BOQ:	Bill of Quantities
CSI:	Construction Specification Institute
CSS:	Cascading Style Sheets
EVT:	Earned Value Technique
HTML:	Hypertext Markup Language
MoWUD:	Ministry of Works and Urban Development
PHP:	Hypertext preprocessor
PMI:	Project Management Institute
PMBOK:	Project Management Body of Knowledge
SQL:	Structured Query Language
WAMP:	Windows, Apache, MySQL, and PHP
WBS:	Work Break Down Structure

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CHAPTER 1 INTRODUCTION

1.1 Background of Study

It is well known that the construction industry is a key economic sector that interlinks other sectors by converting various resources into the physical, economic, and social infrastructure that is required for socio-economic growth. The industry encompasses the process of planning, designing, procuring, constructing, producing, altering, repairing, maintaining, and deconstructing physical infrastructures (MoWUD, 2012). In developing countries like Ethiopia, the benefit of project management is extremely high and proper application is critical since resources are extremely scarce and the achievement of project objectives is extremely important. As most projects in the developing countries are development-related, failure of a project usually has a far-reaching effect beyond financial losses; it may result in "death", or delay of many children's hopes and dreams to go to school or the hope to save many from poverty and frequent drought. Likewise, successes in projects in developing countries may mean a considerable contribution in improving the life of millions (Nega, 2008). Throughout the years however, many construction projects have failed to achieve essential success variables such as cost and schedule. In developing and Sub-Saharan African countries, construction project cost overruns are common indicating that cost management is a challenge for contractors and project team members. Particularly in Ethiopian Construction Industry (ECI), both the private and public sectors have suffered significant financial losses because of cost and time overruns.

One of the reasons is the poor procedures used for project control and record keeping, which is crucial for managers and other construction process participants during the execution of a project. In most construction projects, cost management problems mainly emanate from the cost management functions that are cost estimation, budgeting, and cost control. For instance, according to Abselom (2008) and Tadesse (2006) many contractors in the construction industry use previously prepared unit prices by other contractors that they believe are well-organized contractors without justification of the cost components included in these unit prices. In addition, contractors do not link their cost control to the cost estimation process, as a result, they are unable to provide input for the valuation or price of future bids. Giving feedback to the estimation process is one of the main goals of a cost-controlling system, that enables the creation of a database of cost records with actual production costs and productivity standards (Tadesse,2006).

There is also a lack of competency in estimating and a lack of organized database systems in the Ethiopian Construction Industry regarding cost. In general, a well-established quantity, a clearly defined scope of work and specification, etc. makes a critical component of cost estimates as well as affecting the methodologies employed and ultimately the entire cost of a project. However, the Ethiopian Construction Industry is well known for issuing incomplete drawings, ambiguous specifications, and incomplete scope definitions which ultimately leads to cost overruns (Taddese, 2006). A Research by Nega (2008) on the causes of cost overrun during construction and their effects on public building construction projects in Ethiopia concludes that for specific projects, the rate of cost overrun varies from 0% at the lowest to 126% at the highest. Inflation or an increase in the cost of building materials, poor project cost management, change orders because of client-requested improvements, and excess quantity during construction are just a few of the causes of cost overrun that have been found.

In addition, Angelo and Reina (2002) stated that cost overruns are a significant issue in both developed and developing countries. According to numerous studies of significant projects, cost overruns are common, and there are a variety of reasons why construction projects go over budget, some of which are difficult to predict as well as to control. According to Cox (2007), project owners recognized five causes of project cost overruns: incomplete drawings, inadequate pre-planning, inadequate cost management, rising material costs, and excessive change orders. The accuracy of an initial estimate and the effectiveness of a cost-controlling mechanism have an impact on contractors' gross profit upon project completion. The main obstacles preventing contractors from maintaining a healthy cash flow and getting the expected profit amount from projects are erroneous cost estimates, poor accounting records, and ineffective cost controlling techniques (Hendrickson, 2003).

Several research studies were done regarding cost estimation and causes of cost over run for the Ethiopian construction Industry. However, very little local research on cost control and ways to improve the effectiveness of cost control mechanisms is in place, which actually helps to give feedback to the estimation process. New technologies are helpful and fulfill the dual functions of keeping track of financial data and informing the management about a project's status and the potential issues to look for (Tadesse, 2006). Therefore, this study focuses on developing a activity-based cost control system.

1.1.1 Activity-Based Cost Control in Construction

Robert Kaplan and William Burns first introduced the Activity Based Costing (ABC) idea in the late 1980s. Initially, ABC concentrated on the manufacturing business, where technological advancements and productivity gains had cut direct labor and material costs while increasing indirect or overhead costs (Fayak, 2001). By using the ABC approach, it is possible to link a specific cost element to a specific resource consumption activity. According to Fayak (2001), work packages, which are best planned and monitored by activities, are the best way to handle building projects. According to the researcher, a project planner must use the activity as a common database for planning and monitoring the progress of projects. Then, resource forecasts can be made using the inputs for labour, materials, and equipment needed to complete each job or sub activity.

Activity-Based Cost control offers a straightforward, but efficient way to connect the functions of estimating, scheduling, and controlling with that of job costing. Field data will be gathered and used to evaluate project performance, which will be compared to planned performance, and provide feedback to site and management personnel (Fayak, 2001). Activity-Based Costing can be useful for construction project managers to keep track of their actual job expenses for the activity. Activity-Based Costing in this research is cost accounting for the various types of work or tasks, such as concrete casting, reinforcement, and formwork recorded separately and daily, and the actual costs of these works are recorded and analyzed to compare to the budgeted cost. This research aims to elaborate on the importance of adopting a web-based Activity-Based Cost control method as an alternative method for cost control in building construction projects, aiming for a simple yet effective method of collecting cost information from the field, analyzing actual costs, and providing feedback to project personnel, in addition, to address problems related to cost estimation and control by providing cost records to contractors so that, they make informed decision.

1.2 Statement of the Problem

Cost is a crucial and sensitive element of the construction industry because the operations of contractors, subcontractors, and suppliers depend on the reliability of cash flow from a project. Contractors' profit margins are significantly impacted by the project's actual cost. The Ethiopian Construction Industry shares many problems and challenges as other developing countries perhaps with greater severity regarding the cost management process. According to Abadir (2011), despite the construction industry's considerable contribution to the emerging economy and the critical role it plays (in the development of the nation), the industry's needed level of performance remains generally low ad suggest that 44% of the contractor's cost management process is either incomplete or performed informally. In this regard, many projects suffer not only from cost overruns, but also time extensions, and failure to achieve their intended benefit.

Construction projects also face challenges with management and construction methods in addition to financial and scheduling constraints. The inability to finish projects on time, poor work quality, and cost overruns are the major issues. Generally speaking, time and cost overruns occur during the execution phase of the majority of construction projects, if not in all of them (MoWUD,2006). Additionally, research conducted by Bruktawit (2017), Abselom (2008), and Tadesse (2006) on the main causes of poor cost performance in the Ethiopian Construction Industry concluded that the estimation and control process have a significant impact on project costs. The accuracy of cost estimates, starting in the early stages of a project, determines the success or failure of any construction project. In this regard, the construction industry in our country has poor cost estimating practices, such as poor cost data analysis, estimators who do not understand the construction process and a lack of document analysis.

Asteway's research from 2008 also showed that one of the main goals of a cost-controlling system is to give feedback to the estimation process. However, contractors' cost control in the Ethiopian construction industry is not connected to the cost estimation process and does not provide feedback for the valuation or pricing for subsequent bids. By creating a database of cost records that records actual production costs and productivity standards, this can be made easier. However, the study shows that the majority of contractors do not frequently use the data sources published by the Ethiopian Construction Contractors Association (ECCA) and the Central Statistics Agency (CSA). One of the reasons for this might be that these institutes' price data are released over very long periods of time, whereas the market price of materials fluctuates over very brief periods of time. These factors suggest that there are no well-established methods that give contractors access to the most recent information on resource costs.

Therefore, problems in cost estimation and cost control can contribute to a project completion that is over budgeted, delayed, or even compromises the project's potential benefits (Tadesse, 2006). Examining the underlying causes is essential in order to exercise control even though it is not always simple to pinpoint the cause of overruns or underruns. Typically, the majority of Ethiopian contractors only collect data on profitability as part of expense control efforts. However, a cost-controlling system's scope should go further and cover additional related duties and goals. An efficient cost-controlling system, for instance, should provide data that can increase resource efficiency, provide early warnings of unprofitable operations, and updates to resource planning and costing standards (Abselom, 2008).

In this study a web-based Activity-Based Cost control (ABC) is introduced as an alternative method to other cost control techniques. Even though the application of ABC remains a well-

researched area in other countries for cost accounting and control in different businesses areas, there is no prior research for applying this costing system for construction projects in Ethiopia. With this in mind, the research objective is to design and implement a web-based Activity Based Cost control as an alternative method to other cost control mechanisms, which allows first to have actual cost data of activities in projects then to calculate the actual cost based on activity and compare it with the budgeted cost of each activity, that will ultimately help to improve the cost control system, enable to detect and enhance the cost performance of projects.

1.3 Research Questions

To realize the objectives of the study, the following questions are raised.

- What are the current cost control mechanisms in Ethiopian Construction Industry?
- What are the challenges of cost control in Ethiopian Construction Industry?
- What other approaches can improve the problems related to cost control?

1.4 Objectives of Study

1.4.1 General Objective

This study's primary goal is to develop web-based application software that can be used to collect the actual cost data, analyse, and report based on actual cost of activities.

1.4.2 Specific Objectives

- To assess the current practice and challenges through contextual analysis of prior studies.
- To develop a web-based Activity-Based Cost control as an alternative method for cost control and cost performance tracker.

1.5 Scope and Limitation of Study

The scope of the study is bound by three main aspects: geographical, sectorial, and project stage.

Geographical scope: The area selected for the study is Addis Ababa, the capital city of Ethiopia, owing to time and cost feasibility and a relatively higher volume of construction.

Sectorial Scope: There are various sectors in the construction industry such as roads, railways, waterworks, residential housing, commercial and public buildings, and so on. In this respect, the study is limited to building projects and specific project cases will be selected to collect the data for validation purposes.

Project Stage Scope: The study is limited to the construction stage of a project where a fast, practical, and reliable construction cost estimate and control is needed, in addition, the activity-based cost control system only tracks the actual direct cost of projects. Since the direct cost is the major cost of construction projects that accounts up to (65% of the total project cost).

However, the indirect cost in the study is incorporated as a percentage set by the contractor, and finally a Web-based Activity Based Cost Control technique will not consider other factors that affect the cost of projects in general, as it is designed to input data (cost information) and calculate the actual cost of activities based on them and compare it with the budgeted cost or unit price set for each activity.

1.6 Significance of Study

This study aims to develop Web-based Activity Based Cost Control as an alternative method, which will allow first to have actual cost information in projects; help to provide feedback for the valuation or pricing for subsequent bids; calculate the actual cost based on activity so that it gives an early warning of unprofitable operations; provide data that can boost resource productivity; and update resource planning that will ultimately help to improve the cost control system and enable to detect and enhance the cost performance of projects. The activity-based approach to cost control will provide a simple yet effective method of linking the estimating, scheduling, and controlling functions with each activity. With the development and use of information technology, this web-based application for ABC will serve as a decision-making tool for determining the cost performance of projects.

CHAPTER 2 LITERATURE REVIEW

2.1 Definition of Terms

A) Project

According to Project management institute ((PMI), 2004) project is temporary work (with definite beginning and end time, undertaken after a specific cycle of initiation, definition, planning, execution, and close out to produce a distinctive product, service, or result through organization and coordination of human, material, and financial resources.

B) Project Management

Project management is the process of applying knowledge, skills, tools, and processes to project activities in order to meet project criteria (PMBOK, 2008).

The PMBOK has defined nine essential knowledge areas for project management. These are: scope, time, cost, risk, quality, human resources, communications, procurement, and integration management. Each knowledge area in the PMBOK is made up of procedures that must be addressed to achieve the knowledge area's goal.

C) Cost

The term "cost" can be interpreted as a financial measurement of expenditure paid on or attributable to attaining a specific objective, such as obtaining products or services (Drury, 2012). It may also be referred to as the assets that have been forgone or sacrificed to achieve a specific objective.

D) Construction Costs

“The sum of all costs, direct and indirect, inherent in converting a design plan for material and equipment into a project ready for start-up, but not necessarily in production operation; the sum of field labor, supervision, administration, tools, field office expense, materials, equipment, taxes and subcontracts.” (AACE International Recommended Practice, 2014).

2.2 Construction Project Management

The PMBOK has identified a total of 44 project management processes for the nine knowledge areas. Management of projects is accomplished through the use of the above 44 processes. However, not all 44 processes are intended to be followed consistently when managing all projects. The processes to use and the level of precision to be used in their execution must be decided by the project manager and the project teams (PMI, 2004).

Managing a project typically includes:

- Identifying requirements,
- Addressing the various needs, concerns, and expectations of the stakeholders as the project is planned and carried out,
- Balancing the competing project constraints including, but not limited to:
  - Scope,
  - Quality,
  - Schedule,
  - Budget,
  - Resources and Risk

A specific project will influence the constraints on which the project manager needs to focus. The project manager should take into account other, industry-specific knowledge areas in addition to the nine listed above while managing projects. For instance, the PMBOK extension for construction adds four new knowledge areas of financial, safety, environment, and claim management. The management of construction projects shares many similarities with the management of projects of a similar nature in other industries (Hendrickson, 2008). Construction projects can directly benefit from most of them (PMBOK, 2004).

Even though managing a construction project is comparable to managing other types of projects in many ways, it also differs from managing other types of projects in a few unique situations. In acknowledgment of the difference, PMI has published a supplemental guide for managing construction projects (The construction extension - Guide to Project Management body of Knowledge-3rd edition). In this guide, four additional knowledge areas of Project Safety Management, Project Environmental Management, Project Financial Management, and Project Claim Management are included.

According to Hendrickson (2003) in addition to knowledge of project management and general management, managing construction projects requires an understanding of the design and construction process. Hendrickson (2003) has summarized the functions of project management in construction as:

1. Defining the goals and strategies for the project, including its scope, its budget, its timetable, its performance standards, and its participants.

2. Obtaining labor, supplies, and equipment in accordance with the outlined schedule and plan in order to maximize effective resource usage.

3. The effective coordination and management of planning, design, estimating, contracting, and construction throughout the entire process.

4. Establishing efficient channels of communication and methods for settling disputes among the various parties.

2.3 Components of Construction Project Costs

The main components of a contractor's costs and expenses are the result of labor, materials, equipment, and subcontractors. However, there are general overhead cost components that are taxes, premiums on bonds and insurance, and interest on loans. The sum of a project's direct costs and its allocated indirect costs is termed the project cost, which will be briefly elaborated on below.

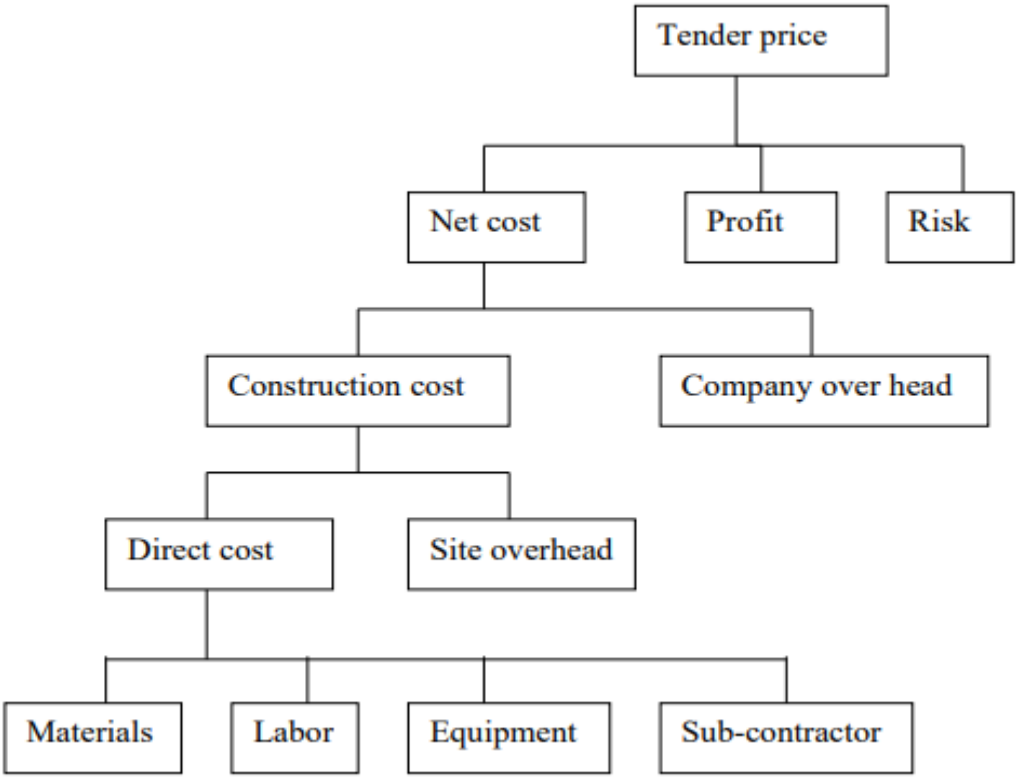


Figure 2. 1 Components of Construction Project Costs, Source: (Plither, 1992).

2.3.1 Direct Cost

The costs incurred for a particular activity are referred to as direct costs. Based on a thorough examination of contract activities, site conditions, resource productivity data, and the construction technique used for each activity, these costs has to be calculated. Direct costs include expenses for labor, materials, equipment, and subcontractors (Chitkara, 2001). The distinctive nature of direct construction costs is that the total expense can be charged to a specific activity in a specific construction project (Tadesse, 2006).

A) Direct Material Cost

Direct material costs represent those material costs that can be specifically and exclusively identified with a particular cost object. According to Chitkara (2001) the direct material cost generally includes:

- Ex-factory costs, delivery to a specific address, or purchase expenses.
- The price of transportation, customs processing, insurance, and handling up until the site.
- The price of on-site production and fabrication to create goods from raw materials for use in long-term projects.

The direct cost of materials excludes labor and equipment installation, and takes into account all costs associated with transportation, freight, delivery, storage, sales, other taxes, and losses in addition to the direct material prices. Eqn. 2.1 shows how to calculate the direct material unit cost.

Material Unit Cost = Σ (Material quantity x Materials unit price) …….[Eqn. 2.1]

The material quantity is determined by the consumption standard, which is the amount of material necessary to complete a certain activity, including any estimated waste allowances. Prices for material units will be obtained from suppliers from a range of sources, including catalogs, vendor price sheets and/or vendor quotations, pricing services, cost data books, historical records, and other resources. For materials to be manufactured on-site or purchased from the local market, the material unit cost can be calculated simply by adding the additional cost of loading, unloading, and transportation to the project on the supplier's invoice. If the item is imported from another nation, the estimator should be knowledgeable with the logistics of imported goods as well as global business terms. He/she should compute these additional expenses and add them to the supplier's pricing to arrive at the material unit price at the project site (Abeselom, 2008).

B) Direct Labor Cost

Depending on their level of involvement, people who are directly or indirectly involved in the project incur labor costs. Direct labor costs refer to all expenses related to workers who perform certain activities, including carpenters, masons, electrician, painters, plumbers, and other workers. The salaries and benefits of all employees, excluding senior management staff working at the head office and those not included in the site management team, are covered by indirect labor costs, which vary depending on the size, kind, and organizational structure of the building project (Tadesse, 2006). The cost estimator shall determine the number of labor, skill, and utilization factor (UF) needed for carrying out the construction work in order to calculate the direct labor crew required for one activity. The direct hourly labor cost and the direct labour cost can be calculated as shown below in equation 2.2 and equation 2.3 respectively.

Direct labor hourly cost=Σ (No of labor x Basic salary x Labor index x UF) ……. [Eqn. 2.2]

Direct labor cost = Direct labor hourly cost / Hourly crew productivity……. [Eqn. 2.3]

i. Determination of Number of Labor

The amount of direct labor needed for a task depends on the number of teams deployed, the activity schedule, the site's condition, the activity's intensity, and the quantity and type of equipment employed. Clough (2015) asserts that labor is both the most expensive and riskiest element of a cost estimate for a construction project because it is also the most challenging to accurately predict. In order to determine the number of people required for the job, Clough (2015) advises using the methods listed below.

1. Building the job in mind-the estimator must determine all the activities that must be performed to complete the work. Activities are defined as elements of work that are identifiable and quantifiable and consume resources.

2. Creating a work breakdown structure.

3. Estimating the number of person-hours necessary for the crew and each of its craft workers to complete every activity that is identified. This component of the labor estimate is both vital and, at the same time, filled with uncertainty.

ii. Determination of Crew Productivity, Utilization Factor, and Labor Index

The best method for predicting crew productivity is to use past cost data that was collected by contractors' cost estimating, cost accounting, and cost control systems. In reality, this is the main justification for the contractors' collection and upkeep of information files. The historical cost data is a tabulation of the payments made by contractors to complete work on earlier projects, broken down by project and activity. This data is created as each project is completed and is organized in a historical cost database.

One of the contractor's most valuable and protected assets is this database (Clough, 2015). Thus, the amount of crew can be obtained from previous experience of works similar in nature, historical data, national /international performance standards, and other trial tests conducted on actual conditions. The utilization factor (UF) is used for calculating the contribution of a crew member for the specific activity who can also be engaged in other or more other activities.

The minimal employee benefits that the cost estimator should include in computing the labor index in Ethiopia, according to proclamation No.377/2003, are listed as follows:

- Severance pays
- Annual leave
- Occupational accident expenses
- Occupational disease expenses
- Overtime pays
- Occupational safety
- Health and working environment and other benefits resulting from collective agreements

C) Direct Equipment Cost

The equipment costs are hard to assess like labor costs. The cost of equipment makes up a significant amount of the total cost of most building projects. However, as a percentage of the total cost of construction, it is often less significant (Clough 2015).

On a building site, a variety of factors might impact equipment selection. These variables can be classified into three groups: site conditions, work nature, and equipment features.

Equipment production rates, like worker production rates, vary significantly and are influenced by a variety of factors on the job site.

Equipment production data can be found in a variety of places, including manufacturer product information, contractor historical records, and operator/machine owner experiences. The contractor's previous project output records are by far the most reliable. In some cases, input from the equipment operators can be extremely beneficial (Chitkara,2001).

When dealing with a new piece of equipment with which you have no past expertise, production data provided by the equipment manufacturer or dealer can be quite valuable. As discussed below, equipment costs are divided into two categories: ownership costs and operational costs.

According to Tadesse (2006), the overall equipment hourly costs should include the equipment owner's overhead expenditures in addition to the equipment's owning and operating costs.

i. Equipment Owning Cost

Equipment ownership costs are defined as expenses that accumulate whether or not the machine is in use. Financing charges for purchasing the machine (or sinking fund contributions for replacing the machine when it reaches the end of its useful life) and depreciation are two examples. Depreciation, insurance, property tax, erection, and installation costs, and significant

repairs and overhauls are all included in the cost of owning equipment (Clough, 2015 and Tadesse, 2006).

ii. Equipment Operating Cost

Equipment Operating costs, as the name implies, are costs related to the machine's operation. Operating expenses are incurred only when the equipment is in use, whereas ownership costs are incurred regardless of whether the equipment is in use.

Fuel, lubrication oils, filters, and grease are all included in equipment operating costs, as tire, undercarriage (in the case of crawl-mounted equipment), regular repairs, and high-wear components. The yearly equipment operator salary and benefits are added together and divided by the annual equipment utilization to get the hourly cost of the operator (Clough, 2015).

D). Subcontract Costs

All tasks in a general contractor's construction project may not be completed entirely by the contractor's own workforce. As a result, subcontractors are hired to complete the work. The cost estimator should identify the work components that will be handled by subcontractors, collect price quotations from a variety of subcontractors, and then factor the selected costs into the cost estimate. In subcontracted work, the cost estimator must also assess any administrative tasks and interference, as well as any scheduling issues. The cost of the general contractor's job will rise as a result.

The subcontract prices are considered the direct cost of the activity when specific activities are subcontracted to subcontractors (Tadesse, 2006).

2.3.2 Indirect Costs

Other costs, such as overhead, are referred to as indirect costs. Each of the company's projects receives a portion of the indirect costs. Project (site) overhead; and General (head-office) overhead are the two types of indirect costs.

A) Project Overhead

Project overhead costs are site-related costs that include items that cannot be directly charged to a specific work element and can be either fixed or time-related. These expenses include site utilities, supervisors, project staff housing and feeding, parking facilities, offices, workshops, stores, and a first-aid facility. It also comprises plants that are needed to support working teams in various operations.

To arrive at an accurate estimate of these costs, a detailed analysis of the various elements of site-related costs is required. Companies, on the other hand, used to create their own forms and checklists to estimate these costs. The cost of sitting overhead is expected to be between 5% and 15% of the overall direct cost of the project (Chitkara,2001).

B) General Overhead

According to Chitkara (2001), general overhead refers to costs that cannot be directly attributed to a specific project. These are the expenses incurred to support the company's overall operations. They cover head-office expenses such as managers, directors, design engineers, and schedulers, among other things.

Observing the company's spending on a regular basis will give an excellent notion of how to estimate appropriate numbers for general overhead expenses. The general overhead for a single contract can be anticipated to be between 2% and 5% of the contract's direct cost in most cases. The amount of general overhead that should be assigned to a particular project can be calculated as shown in equation 2.4 below.

$$\frac{\textbf{Project Direct Cost} * \textbf{General Overhead of the company in a year}}{\textbf{The expected sum of of Direct cost of all projects during the year}} \quad \textbf{..... [Eqn. 2.4]}$$

2.3.3 Risk Allowances

Risk is the exposure to the possibility of things happening that could have a positive or negative impact on project goals due to uncertainty. The following are some of the risk circumstances that estimators must consider (Plither,1992).

- the contractor's ability to manage variables like the productivity of resources assumed during estimation.
- the contractor's capacity to influence elements like resource productivity assumptions made during estimation.
- bad weather and possible delays it might bring about.
- the client's financial stability.
- the performance of the equipment
- the availability of materials for incorporation in the job
- delays brought on by labor disputes.

Contingency is the sum of money added to an estimate to account for unanticipated project requirements, construction challenges, or estimation accuracy. The term "contingency" in estimation refers to two different kinds of estimates. The first is the anticipated outcome of the detected potential event. The potential expense of unforeseen events constitutes the second category of contingency. Because the engineer does not know what might occur in the future, it is hard to pinpoint certain events. Because there is a margin for mistake, the second category, which is a true contingency, requires great attention (Ostwald, 2001). Ten percent (10%) of the project's total cost is customarily treated as the contingency in Ethiopia. Consultants typically calculate this cushion to protect the project budget (Taddese,2006). Ostwald (2001) noted the key factors that prompt many estimators to include a contingency in the estimate to cover one or perhaps more of the following:

- Unpredictable price increases for labour, installed equipment, and materials for projects with a projected duration longer than a year.
- Project difficulty
- Incomplete working drawings while performing the detail estimate.
- Soft spots in the detailed estimate due to potential estimating errors, to balance an estimate that is biased low.
- Incomplete design in the fast-track or design-build contracting strategy.
- Unusual start-up needs and construction techniques.
- Estimator's personal project worries, unexpected construction risk, and building challenges.
- Unexpected environmental and safety needs.

2.3.4 Profit

Profit is the amount of money that will belong to the contractor after the project is finished and all associated costs have been covered (Plither, 1992). According to Plither (1992) “The project's estimated level of risk has a big impact on the percentage of profit that is contributed. “Because risk and cost typically go hand in hand. On the other hand, Tadesse (2006) asserts that the profit margin is entirely reliant on the market's level of competition and the company's strategy.

2.4 Project Cost Management

One of the expertise areas of project management is project cost management, which covers project cost estimation, planning, and control, to guarantee that the project is completed within the allocated budget. The cost of the resources required to accomplish project activities is the main focus of project cost management. Project cost management should also take into consideration how project decisions will affect the ongoing costs of using, maintaining, and supporting the project's product, service, or output (PMBOK, 2008).

The Project Cost Management processes include the following:

Estimate Costs: The cost estimating approximates the resource cost in currency to complete the planned set of activities including the variation and risks.

Determine Budget: The cost budgeting aggregates the estimates into the activity level, this allows the cost control and measurement of the project's performance. The cost budgeting is very important for keeping the project's cash flow on the positive side.

Control Costs: The process of monitoring project progress to update the budget and handle alterations to the cost baseline. The cost control focuses to search the cause for negative or positive variance between budget and realized result. Cost control is an important part of risk control and learning (PMBOK, 2008).

These processes interrelate with one another and with processes in the other knowledge areas. Depending on the needs of the project, each procedure may require the effort of one group or person.

2.4.1 Elements of Project Cost Management Processes

The cost of utilizing, maintaining, and supporting the product, service, or project results are taken into account as part of project cost management, which takes a more comprehensive approach to life cycle costing. However, the cost of resources required to execute planned tasks during the execution stage is what it is mostly concerned with (PMBOK, 2008).

The project cost management process includes the sub-processes involved in planning, estimating, budgeting, and controlling costs so that the project can be finished within the authorized budget, according to PMBOK guidelines (2008). However, it defines the primary and discrete processes of a cost management system as cost estimating, cost budgeting, and cost control. These elements of cost management processes are referenced from the PMBOK guidelines (2008) and later contextual analysis is done for the Ethiopian industry practice by comparing with the guidelines.

2.4.1.1 Cost Estimation

One of the most crucial phases of project management is cost estimation. At various stages of the project's development, A cost estimate establishes the project's cost as a starting point. A cost estimate is a forecast produced by the cost engineer or estimator based on the information available at a particular stage of the project's development (Henderikson,2003).

Cost is a major factor in most decisions regarding construction, and cost estimates are prepared throughout the planning, design, and construction phases of a construction project, different types of cost estimating from preliminary to detailed are conducted for different purposes.

Cost estimation is the process of analyzing a specific scope of work and predicting the cost to do it. The primary responsibilities of a construction contractor are assessing project costs, planning specific building tasks, and ultimately finishing the project within the specified budget and time frame. Cost estimation must be done in a variety of methods and at a variety of phases

to get an accurate, cost-effective estimate of how much a project will probably cost (Elbeltagi,2015).

Cost estimating is a challenging process that necessitates obtaining all relevant and available data regarding the project's scope, anticipated resource consumption, and potential price changes for those resources. The estimate cannot be expected to be precise because there is little information available at the beginning of a project.

A qualified estimator needs to be able to visualize the entire structure before a project is completely designed. He or she must have clear thinking and an understanding of the details of the project. The estimator also needs to have the ability to anticipate design choices and articulate the presumptions used in conceptual estimating. He or she must also be knowledgeable in engineering design, accounting, taxation, law, and economics, in addition to the anticipated lifespan of building materials (Elbeltagi,2015).

A good estimator should have technical expertise, attention to detail, a strong memory, and familiarity with the building process. Additionally, he or she should be capable of planning the project, be aware of similar costs, and use solid judgment.

If an estimator spends too much time and effort researching pointless minutiae to ascertain the costs of inconsequential items, estimation will take time and cost money. 20% of the items in a bill of quantities for a civil engineering project have 80% of the costs, and vice versa.

Detailed plans, specifications, site data, resource data (labor, material, & equipment), contract documents, resource cost information, necessary government regulations, and applicable owner requirements are all needed for good cost estimating.

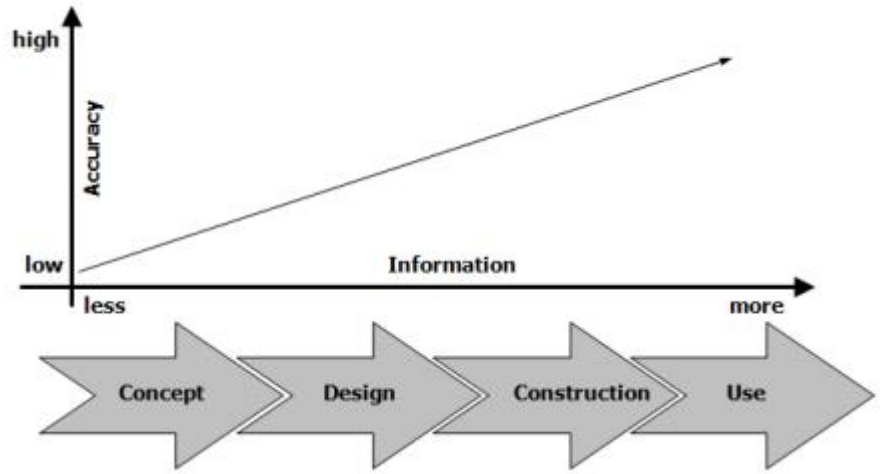


Figure 2. 2 Cost Estimation Stages, Source: (Elbeltagi,2014).

Inputs to the Cost Estimating Process

This section offers a comprehensive, but not all-inclusive, overview of the data points and inputs used in the estimation process.

A) Contract Documents

The contract document, which includes the general and specific conditions of the contract, technical requirements, drawings, an estimated bill of quantities, the method of measurement,

and other supporting documents, must be carefully examined because it has an impact on both the process and the results of the cost estimates.

B) Project Scope Statement

It lists the project's deliverables and its acceptance standards.

C) Construction Method Statement

After having a clear understanding of the project through site visits and the contract agreement, the creation of a construction method statement is an essential next stage in the cost estimation process. Each project activity's building technique statement describes the steps that will be followed.

According to Tadesse (2006), the statement should explicitly state the level of expertise required, the required equipment type and specifications, the required quantity and quality of materials, the proposed working crew, the estimated crew productivity, the estimated time needed to complete the project, as well as any anticipated defects and corrective actions.

D) Project Works Break Down Structure

Breaking down the works to be estimated into work activities is just as significant as creating the method statement for the estimating process (Plither, 1992). The term "Work Break Down" refers to a unique piece of work that can be specifically identified so that its resource requirements, commencement, content, and completion time can be easily recognized.

A project's hierarchy is displayed via the Work Break Down structure (WBS). It facilitates the creation of appropriate job tasks, the connections between them, and the upcoming schedule. In order to make the budgeting and controlling procedures easier, the various levels and WBS components are crucial.

E) System for Project Activities Coding (Activity Codes and Cost Codes)

A summary of the work described in each WBS component is provided, together with the project coding system and any related specific statements of work.

F) Commercial database

This assists in giving labor, material, and equipment resource cost rates (PMBOK guidelines, 2008). Historical information and project files, if properly maintained, can provide comprehensive data for cost estimations.

Cost Estimating Tools and Techniques

From extremely thorough cost breakdowns to comprehensive cost analyses used for comparison and control, there are many different cost estimate approaches available (Hendrickson, 2003). Several methods have been identified by numerous standard textbooks and research articles on cost estimating. The methods that are most frequently applied among these are listed below.

A) The Standard Estimating Procedure or Traditional Method.

According to Akintoye (2000), many construction companies employ the conventional estimating approach, which establishes the cost of construction (labour, materials, and subcontractors) and adds an allowance for overhead and profit. By using the lowest degree of information possible, the cost of individual work packages or schedule tasks is estimated using this method, also known as bottom-up estimating.

B) Analogous Estimating

Analogous estimation refers to estimating a project's cost based on the actual costs of earlier, similar projects (PMBOK guidelines, 2008). It makes use of professional judgment and is most trustworthy when past projects were actually similar, not merely visually.

This approach is known as a "comparison method" by Ostwald (2001). According to Ostwald, by employing this technique, Contractors will refrain from estimating from a base of no information, and adding or subtracting will begin with an option of the border estimates.

C) Probability Approaches

Estimates are typically generated as an average concept (Ostwald, 2001). The estimate also says nothing about how likely it is that the expected values will occur. It makes use of deterministic or certain information.

The idea of range estimating derives from the realization that cost is a random variable. A random variable is a function with a numerical value that represents the results of a sampling of data. Ostwald (2001) claims that calculating the mean or standard deviation using sample data results in a random variable.

D) Parametric Estimating

When estimating costs for a planned activity, the method known as parametric estimating it employs a statistical correlation between historical data and other factors. (PMBOK, 2008). Because it is not designed to create comprehensive estimates, parametric estimating is not frequently utilized by contractors (Akintoye, 2000).

E) Other Techniques

Other estimate methods, according to Akintoye and Fitzgerald (2000), include the use of software, the application of basic or complicated statistical models, the use of available price data, the exchange of information with other construction businesses, guesswork, and intuition.

Table 2. 1 Advantages and Disadvantages of the Tools and Techniques used in Cost Estimation

Tools and Techniques	Advantages of the tools and technique	Disadvantages of the tool and technique
Expert judgment	• It eliminates estimation errors and makes common sense of the generated numbers. • Expert judgment is indispensable when you need to identify difficult correlations among different cost variables and project-related factors and verify the accuracy of computer-supported calculations. • Can be useful in combination with other methods for more comprehensive detail	• Regardless of how knowledgeable and skilled humans may be, they are prone to make mistakes, whereas their judgment is frequently influenced by emotion and prejudices. • The cost estimate may vary depending on the expert consulted
Analogous estimating	• It does not require data manipulation or statistical adjustments. • Analogous estimating typically does not require a lot of resources or time.it is therefore ideal in the project initiation phase and for activities for which not much information and historical data are available. • These estimates can be ideal for high-level assessments and strategic considerations, as the accuracy is often sufficient for working on the 'big picture'.	• Needs the estimators' experience or historical data from previous projects. • Estimates tend to be rough, and they are often not very accurate. • The underlying assumption is that historical data or experience of the estimators would be applicable to the current project. If it turns out that this assumption was incorrect, the estimate will be useless. • In practice, top-down estimates can sometimes be driven by political considerations or even pressure rather than based on the project-specific characteristics or the expertise of the subject matter experts.
Parametric estimating	• The parametric estimation technique can be very accurate when it comes to estimating cost and time. • It is therefore easier to get stakeholders' support and approval of budgets determined this way. • Once the model is established, it can be reused for other similar project and the quality of data becomes better with every additional project. • Manual adjustments to the calculated results to account for differences between historic and the current project can help address weaknesses.	• The required availability of historic data and the expected scalability are further constraints for the use of this technique. • It can often only be used for some parts of a project while others need to be estimated with different techniques. • Relying on the data may not be appropriate if certain factors differ between the current and previous projects. • The quality of the historic data may also be an area of concern in some cases. The saying 'garbage in, garbage out' applies to parametric estimating in the same way it is true for any other use of data. • The quality also depends on the quality of mathematical algorithms and equations used.

Tools and Techniques	Advantages of the tools and technique	Disadvantages of the tool and technique
Bottoms up Estimating	• Bottom-up estimating presents accurate estimates. The responsibility lies on team members who perform the work and state the requirements, thus being an authentic source. • It provides an opportunity to balance the excess or less hence not compromising the project and its efficiency. • It can be used with other validation techniques and different centric estimations.	• It ignores integration efforts usually found in complex and large projects. • The duration estimate depends on the cost estimate, which increases the chance of miscalculation affecting the overall endeavour. • Requirement of high resources • It involves multiple estimators, which may lead to biased results.
Three points Estimating or Probability approach	• Can be refined by adding weight to individual scenarios. May provide inaccurate estimates if the assumptions those scenarios are based upon are incorrect or inaccurate. • May provide inaccurate estimates if any one (or more) of the individual scenarios used are skewed Can be time-consuming and confusing (especially if different people define "optimistic," "most likely," and "pessimistic" differently)	

In summary, each cost estimation technique has its advantages and disadvantages, and the best approach is often a combination of multiple methods that suit the specific projects' need. Accurate and comprehensive cost estimation is an essential aspect of construction planning and execution and can significantly affect the success of the project. It is important to note that having the historic data is valuable in applying most of the listed estimation techniques.

Outputs from the Estimated Costs

A) Activity Cost Estimates

Activity cost estimates are quantitative assessments of the probable costs required to complete project work. Cost estimates can be presented in summary form or in detail. Costs are estimated for all resources that are applied to the activity cost estimate. This includes, but is not limited to, direct labor, materials, equipment, services, facilities, information technology, and special categories such as an inflation allowance or a cost contingency reserve. Indirect costs, if they are included in the project estimate, can be included at the activity level or at higher levels.

B) Basis of Estimates

The amount and type of additional details supporting the cost estimate vary by application area. Regardless of the level of detail, the supporting documentation should provide a clear and complete understanding of how the cost estimate was derived. Supporting detail for activity cost estimates may include:

- Documentation of the basis of the estimate (i.e., how it was developed),
- Documentation of all assumptions made,
- Documentation of any known constraints

C) Project Document

Updates Project documents that may be updated include, but are not limited to, the risk register.

2.4.1.2 Determination of Budget

Determining the budget is the method of combining the anticipated prices of several tasks or work packages to establish a reasonable cost baseline. All allowed budgets are included in this baseline, but management funds are not. The project budget includes the funds allocated to finish the project. The cost performance of the project will be evaluated against the approved budget. A budget's primary objective is to assign financial objectives and resources to each activity & serve as the foundation for performance management and to instill cost consciousness in project participants.

In projects, cost budgeting entails combining the expected prices of specific schedule activities or work packages to create a baseline for overall costs used to estimate projects performance (PMBOK, 2008). For building projects, budgets are created by both owners and contractors. According to Chitkara, 2001 The owner's budget includes all of the costs that the owner will need to pay in order to complete the construction project. This will typically include things like the cost of purchasing the land, paying for building permits, hiring professionals like architects and engineers, materials, labour, and any other costs associated with the project. The owner's budget will also need to consider contingencies in case of extra costs. On the other hand, the contractor's budget includes the costs associated with the actual construction work. This typically includes things like labour, equipment rental, subcontractors, materials, and overhead costs. The contractor's budget will also include a profit margin, which is the amount of money that the contractor will make from the project.

It's important to note that while the owner's and contractor's budgets may seem separate, they are inextricably linked. The contractor's budget must fit within the owner's overall budget for the project to be successful. The owner must make sure that the contractor's budget includes all of the necessary costs while also staying within the overall project budget. Good communication and planning between the owner and contractor are critical to ensuring that the project stays on budget and is completed successfully.

Inputs to Construction Budget

A) Work Break Down Structure.

The relationship between all of the project's components and its deliverables is provided by the project's works breakdown structure (WBS). The project break-down method makes it possible to divide the project work into hierarchical levels, each of which represents a distinct task that requires time and resources.

The method aids in the identification of activities, allowing time and cost to be calculated and activities and work items to be correlated with budgeted earned value. The work breakdown levels that are used in cost budgeting should match those that are used in cost estimating, or the levels that are used in estimating should serve as the basis for the levels that are used in budget preparation.

B) Cost Codes

Codes are used to identify the pricing data related to each activity or work package. An appropriate numbering or coding scheme must be used when creating or implementing a system of cost accounts in order to promote information sharing and the accurate aggregate of cost data. In order to show the costs connected with certain projects and the costs for specific objects across an organization, specialized cost accounts are employed.

C) Activity Cost Estimates

To calculate the estimated cost for each work package or work break-down level, the cost estimate for each scheduling activity inside a work package or other work break-down levels is combined. For the goals of accounting and budgeting, Chitkara (2001) states that production costs and earned sales values are recognized for each task or level of the work breakdown structure.

The direct and indirect expenses related to the activity, which are also discovered during the cost estimate process, are added to obtain production costs. The value of the job finished that the client has committed to pay for the satisfactorily performed works is known as the earned value or the activity contract value. Information about material quantities and labor inputs for each job is also provided, in addition to cost figures.

D) Project Schedule.

The project schedule details the intended beginning and ending times for all of the project's activities, milestones, work packages, and control accounts. In accordance with PMBOK recommendations from 2004, this data is utilized to group expenditures to the calendar periods during which costs are anticipated to be incurred.

F) Contracts

For predicting cash flows, the contract documents indicate the method of payment for completed work.

Tools and Techniques to determine Budgets.

1.Cost Estimating Software

Using cost estimating software is a popular and accurate technique to determine construction budgets. These software programs have a database of information for various projects and can help calculate the cost of construction for a specific project based on various parameters such as materials, labor, and equipment costs.

2. Historical Data Analysis

Historical data analysis involves examining previous construction projects to determine what the project cost was and why. This technique can be particularly useful for companies that frequently work on similar types of projects.

3. Quantity Surveying

Quantity surveying involves examining the quantity of materials needed for a project and using that information to determine costs. This technique requires a good knowledge of construction materials and the ability to estimate how much of each material will be needed.

4. Value Engineering

Value engineering aims to identify ways to improve performance while reducing cost. This technique involves collaboration between various stakeholders in a construction project to find ways to optimize the use of resources while achieving project goals.

5. Benchmarking

Benchmarking involves comparing costs for similar construction projects to determine what the budget for a new project should be. This technique is most useful when there are few reliable data points available for a given project type.

6. Bottom-Up Cost Estimation

Bottom-up cost estimation involves breaking down a project into small tasks and estimating the cost of each task separately. This technique can be time-consuming but provides a very accurate picture of what the final cost of a project will be.

Advantages and disadvantages of Tools and techniques to determine construction budget.

Table 2. 2 Advantages and Disadvantages of Techniques in Determining Budgets

Tools and Technique	Advantage	Disadvantage
Cost Estimating Software	• Accuracy and speed of calculations • Can handle complex calculations and large amounts of data. • Can include real-time cost updates and automatized integration with different project management software.	• Initial set-up costs and learning curve for users. • May not account for unforeseen costs that are not built-in the software. • Cost of repeated license renewals
Historical Data Analysis	• Access to reliable cost data based on previous projects. • Ability to identify cost savings by comparing project costs from different project or phases	• Previous data may not apply to the current project, due to site specific factors, material quality or other variables. • Changes in materials prices, regulations, and technology may not be accounted for on past projects
Quantity Surveying	• Accurate calculation of material quantities and labor requirements. • Useful in identifying and preventing cost overruns by closely tracking expenses	• Accuracy depends on experience of the Quantity Surveyor. • Additional work required to update quantity surveys throughout different phases of the project.
Value Engineering	• Potential for significant cost savings. • Can lead to better quality, safer or long-lasting buildings that meet project goals	• Requires collaboration within the stakeholder's group for the project goals. • Cost savings may lead to changes that interfere with project goals
Benchmarking	• Comparison with similar projects for accuracy. • Insight into project scope of work with industry standards	• Difficult to find reliable comparative data for some projects. • May not account for unique elements of the current project.

Tools and Technique	Advantage	Disadvantage
Bottom-Up Cost Estimation	• Allocation of costs to each specific task. • Greater accuracy in overall project budgeting	• Time-consuming method. • Difficulties in dealing with a complex project with a lot of tasks

These techniques have their unique advantages and disadvantages, and the suitability of each for a particular project depends on the specific project and its requirements. A combination of these techniques may be used to obtain a more accurate budget estimate.

Outputs of the determined Budgets

1. Cost Performance Baseline

The cost performance baseline is an authorized time-phased budget at completion (BAC) used to measure, monitor, and control overall cost performance on the project.

2. Project Funding Requirements

Total funding requirements and periodic funding requirements (e.g., quarterly, annually) are derived from the cost baseline. The cost baseline will include projected expenditures plus anticipated liabilities. Funding often occurs in incremental amounts that are not continuous, which appear as steps. The total funds required are those included in the cost baseline, plus management reserves, if any.

3. Project Document Updates

Project documents that may be updated include but are not limited to:

- Risk register,
- Cost estimates, and
- Project schedule.

2.4.1.3 Cost Control

To ensure that the building's cost stays within the budgeted amount, cost management is a technique used during the construction process. Cost control during the design phase and cost control by contractors after the project has started construction can be classified into two categories.

All subsequent project monitoring and cost management can be done on the basis of the construction plan and the associated cash flow estimates. By comparing individual task progress to the project timetable and evaluating the success of milestone completions, schedules allow for the tracking of project progress.

The first detailed cost estimate is frequently converted into a project budget for control and tracking purposes. Then, the project budget is used as a management guide. Job cost elements are created using information from the detailed cost estimate.

Chitkara (2001) defines cost control as a comprehensive collection of cost accounting procedures and management activities with the overarching objective of improving corporate cost-efficiency by reducing or at the very least restricting cost growth.

Cost control is a tool used by businesses to track, assess, and most importantly improve the effectiveness of crucial aspects of their operations. Now a days, implementing effective cost control measures is becoming more critical to remain in operation.

Many of the challenges of project control raise mainly but are not limited to the following factors:

1. Managing project changes
2. Inaccurate reports
3. Budget forecasting
4. Inefficient process and systems
5. Failure in applying cost control measures effectively.

Nunnally (2007) asserts that monitoring project costs and job progress involve measuring and gathering the project's cost record. It also involves contrasting actual progress with the original plan. The major objective of project cost control is to maximize profit while maintaining a high level of quality in the least length of time. Controlling construction costs attempts to:

1- To limit the client's costs within the amount agreed. In simple terms, this means that the tender sum and final account should approximately equate with the budget estimate.

2-To achieve a balanced design expenditure between the various elements of the buildings.

3- Cladding, insulation, finishing, services, and other elements of the building will be properly related to the class of building and to each other.

4- To provide the client with a value-for-money project. This will probably necessitate the consideration of a total-cost approach.

Chikatra (2001), identifies that there are three purposes of a contractor's cost-control system:

- to provide a means of comparing actual with budgeted costs and thus draw attention, in a timely manner, to operations that are deviating from the project budget.
- to develop a database of productivity and cost-performance data for use in estimating the costs of subsequent projects.
- to generate data for valuing variations and changes to the contract and potential claims for additional payments.

Two related outcomes are expected from the periodic monitoring of costs:

1. Identification of any work items whose actual costs are exceeding their budgeted costs, with subsequent actions to try to bring those costs into conformance with the budget.
2. estimating the total cost of the project at completion, based on the cost record so far and expectations of the cost to complete unfinished items.

Therefore, an efficient system for managing project costs should produce data that boosts resource productivity, allows understanding of time and cost behavior, offers early warning of potential threats, and updates resource planning and costing standards (Chitkara 2001). Contractors who carry out contracted work are responsible for paying for all site expenses, including those related to labor, supplies, equipment, and capital. In addition, contractors must pay for statutory fees, insurance, depreciation, and other expenses. As a result, contractors must manage their finances in order to occasionally satisfy cash needs.

According to Plither (1992) argument, cost management by contractors serves three purposes. As a result, the first and most important daily application of a cost control system is to draw attention to any operation that is being performed under a contract but is showing to be uneconomic for the contractor right away. A cost control system's second purpose is to give feedback to the estimator who initially set the tender's price and will be in charge of setting it for more tenders in the future. Thirdly, the cost control system will supply information for the value of potential contract-related variations. Any controlling process should proceed logically, identifying the parameters to be tracked, creating performance measurement baselines, and accounting performance, which involves tracking performance and reporting deviations. Control systems are used to manage the costs of construction projects, the element to be controlled is the project cost. Project management gathers actual costs (feedback) and compares them to the project budget. See Figure 2, Construction Cost Control Cycle.

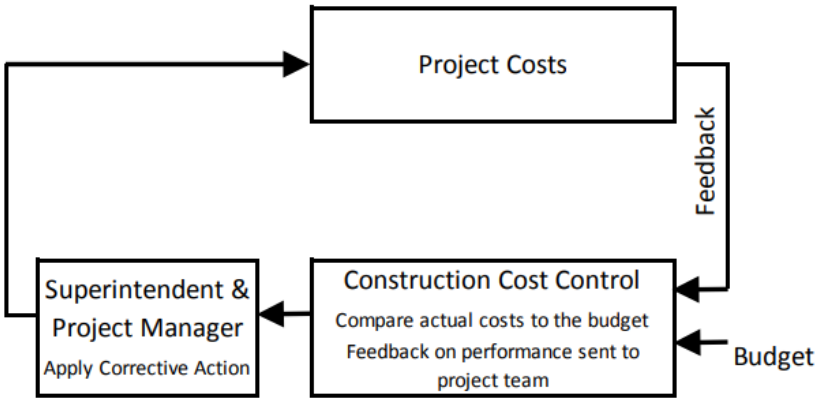


Figure 2. 3 Construction Cost Control Cycle, Source: (Orczyk, 2018)

Project management must act quickly to address deviations in order to reduce cost overruns. In order for this comparison to be accurate, a reasonable budget must first exist. Tracking and analyzing cost performance in construction projects begins with the budget. The project budget is a crucial component of a successful cost-controlling system. Monitoring and regulating budget changes is the aim of project cost control. Cost variations must be analyzed and contrasted with actual costs to determine whether expenditures are running over or under budget.

Control Costs Inputs.

The inputs of construction cost controls include various types of data about the construction project such as the

1. **Project Budget**

Project budget consists of the cost Performance baseline and the cost management plan. The cost performance baseline is compared with actual results to determine if a change, corrective action or preventive action is necessary. Cost management plan. The cost management plan describes how the project costs will be managed and controlled.

2. **Scope of project**

The scope of the project outlines what the project entails and what deliverables are required. Within this scope, the project manager identifies required resources, materials and labour that

will affect the overall budget of the project. Therefore, the scope of the project directly impacts the project budget.

3. **Project Schedule**

The project schedule identifies the duration of the project and when each activity is scheduled to take place. The schedule enables the project manager to plan for resources, labour and expenses, which may vary in cost depending on the time of the year and the project's geographic location. The project manager can use the schedule to predict any variations in cost and plan appropriately.

4. **Project Team Structure**

The structure and skill set of the project team can affect the project cost. The project team determines how much money is allocated to labour cost and also determines the project's overall efficiency. The skill set of the project team determines the quality of work done and the time taken to complete a task.

5. **Procurement plans**

Procurement plans inform which resources and materials are needed for the project. These plans outline the contractor's costs in supplying the goods and the delivery time. The procurement plans may also include cost-saving measures that the project manager uses to manage the overall project cost.

6. **Project Management Plan**

The management plan informs how the project will be executed, monitored and controlled. The plan includes strategies for controlling expenses, such as contingency plans and risk management. The project management plan informs how the project manager will keep track of the project's expenses and ensure that all project drivers are in line with the budget.

Project Cost Control Techniques

1. **Earned Value Control**

The earned value method has been created as a tool to speed up project development. By projecting current patterns, it enables project managers to make predictions about the project's overall duration (Chikatra, 2001).

By relating technical, time, and cost performance, earned value management provides a foundation for assessing work progress against baseline plans. It also provides data for proactive management action and gives managers a summary to aid in decision-making.

Parameters for Earned Value Computation

Prior to the computation of the relevant parameters in EVM, the following should be updated.

- Revise the schedule in account of the work made so far.
- Update the actual cost incurred for the present progress.
- Calculate ratios and key value variation (cost and schedule variance) (cost index, schedule index, resource and schedule index)

The input data required to calculate the variances in project status and the extent of the variances in EVM are as follow (Czarnigowska, 2008)

Budgeted Cost of Work Performed (BCWP): also known as earned value. It measures the value of the activity done at a particular time.

Budgeted Cost of Work Scheduled (BCWS): Also known as planned value. It is the cost of work planned/scheduled as at date of review.

Actual Cost of Work Performed (ACWP): This is the actual amount/cost incurred as a result of executing the project up till the date of progress reporting.

Budget at Completion (BAC): This is the overall budget or total budget allocated to the project.

Estimate at Completion (EAC): This is the activity, work package, or project's updated budget. Since it is the estimated cost of the project at completion, if the ACWP is lower than the BCWP, the EAC will also be lower than the BAC.

There are three methods of calculating EAC. The first assumption is that the current variance will continue to be present in the future then the formula used will be EAC = AC + (BAC – EV)/CPI Secondly, when the present variances are typical and are not expected to occur in the future then, EAC = AC + (BAC – EV). Lastly when the past estimating assumptions are not valid and fresh estimates are applied then, EAC = AC + ETC.

Estimate to Completion (ETC): This is the total expected cost of the project- that is, the estimate required to complete the remaining part of the project, ETC = EAC-AC.

Then to get the key indices in Earned Value Analysis.

Cost Variance (CV): This is a measurement of the variations/differences between the anticipated and actual costs of the job done as of the review date (BCWP-ACWP).

In this case, a positive value indicates that the project is running below budget, whereas a negative value indicates that the project is being cost overrun with respect to the budget.

Schedule Variance (SV): This represents the difference in time between the anticipated and real progress. BCWP - BCWS = SV. A negative value means the project is running behind schedule, while a positive value means it is moving ahead of schedule.

Cost Performance Index (CPI): This ratio demonstrates the effectiveness of resource allocation to initiatives. CPI is calculated as BCWP divided by ACWP. A value above "1" indicates good utilization efficiency, and a value below "1" indicates poor utilization efficiency.

Schedule Performance Index (SPI): demonstrates the effective use of the project's time. BCWP/BCWS Equals SPI. If the SPI number is greater than "1," the project's time is being used effectively; if it is lower, the project's time is not being used effectively.

Czarnigowska (2008) claims that the EVM method has become a standard in project management because it is acknowledged as one of the helpful tools used by many practitioners and public organizations. The approach has proven to be adaptable enough to be used for any project type, from information technology and defense-related tasks.

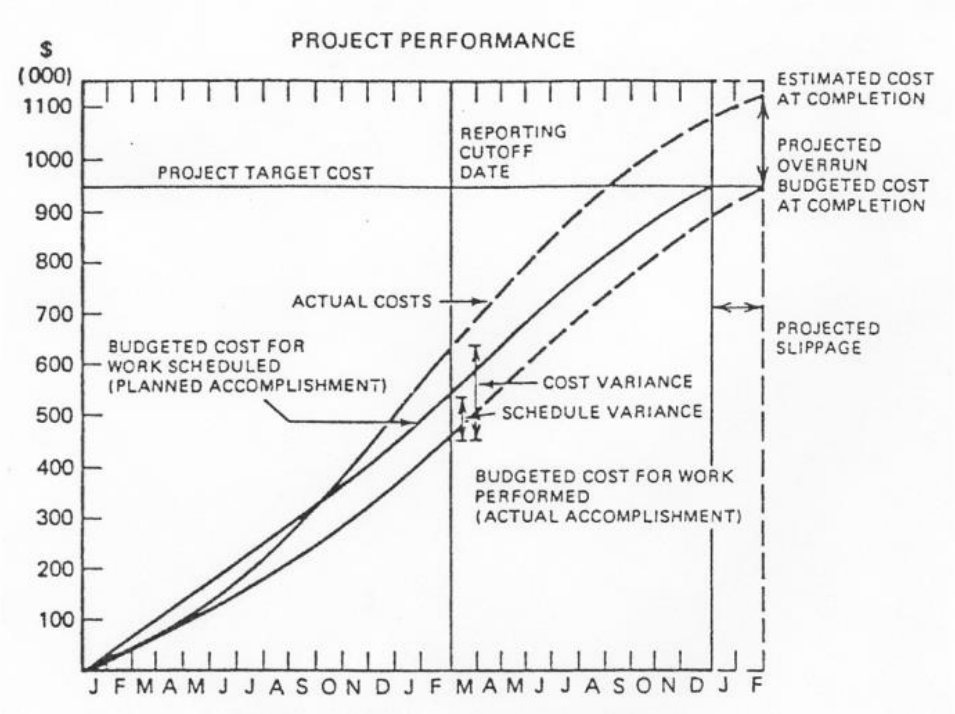


Figure 2. 4 Performance Curves, Source (Ahuja et al., 1994).

2. Time Cost Trade Off

According to Kotb et al. (2016), cost and time are the two fundamental factors that form the basis of project control. Controls are established before the actual production or execution task begins and remain completely operational until the project is finished.

The kind and number of resources used frequently impact the duration of an activity. For instance, adding more workers to a specific activity typically shortens its duration, and this can lead to higher expenses and poorer quality. One of the drawbacks of the critical path technique is that it cannot bring the project schedule to a predetermined duration. Time Cost trade-off is a crucial management instrument for overcoming this limitation (Elbeltagi,2015).

Activity time can be reduced by one of the following ways:

- working on holidays or vacations.
- Adding more resources
- Using numerous shifts or having employees work longer hours.
- utilizing materials, machinery, or equipment with a shorter operating time (Elbeltagi, 2015).

The above implies additional expense, so when cost is limited, it also affects the project's duration, and the primary goal is to arrive at the absolute minimum. The direct cost of that specific activity will always go up as duration is cut. It is crucial to keep in mind that the cost of accelerating any activity within a project is presumptively linearly related to the duration of the activity, such that the cost decreases as duration rises and vice versa. With a clear understanding of both the direct and indirect costs, time cost trade-off analysis creates a schedule of project activities to determine project duration and the lowest possible overall project cost.

3. Building information model (BIM)

BIM is a digital representation of a facility's structural and practical details. Before the construction project is actually carried out, it enables the building to be constructed virtually. Denis (2015) claims that it is a three-dimensional representation of a structure in which each component is seen as an object that is connected to the others. The motivation behind BIM is the wish to efficiently allocate and use the enormous but limited resources needed to build a construction project. Contractors can quickly identify deviations during the implementation process thanks to it.

BIM is used in cost management, construction management, project management, and facility operation. It extends beyond the planning and design stage of the building project lifecycle, supporting and controlling construction processes in order to minimize resource waste overall, improve safety, reduce uncertainty, solve problems quickly, and simulate and analyze potential effects.

4. Forecasting

Forecasting uses the information that is gathered performance of the project based on what is known when the calculation is performed. Forecasts are based on work performance information (an output from the executing process group) and predictions of future performance. Forecasts are generated, updated, and reissued based on work performance data that is provided while the project is being executed. The work performance information covers the projects project in the future.

5. Reserve Analysis

Reserve analysis is used to monitor the state of the project's management and contingency reserves during cost control in order to ascertain whether these reserves are still required or whether more reserves should be requested. These funds may be used as intended as the project moves forward to pay for risk mitigation activities or other unforeseen expenses. To free up funds for other projects or activities, the unused contingency reserves could also be removed from the project budget if the likely risk events don't materialize (PMI, 2004).

6. Activity-Based Cost Control

Activity-based costing (ABC) was first developed for the manufacturing industry in modern accounting standards. Some services in businesses and technology firms are now using ABC. It was created largely to solve the allocation of indirect (overhead) costs.

ABC divides each good or service into a number of distinct activities, each of which requires resources and has a price. Contributions to a product can be direct or indirect (Fayak,2001). An activity hierarchy can be created to reflect several stages of product development. A single product or service is the subject of several related activities.

The value of a product or service is determined by the total cost of all resources used in all of its associated activities. As a result, each good or service gets its fair share of the indirect costs attributed to one or more of its activities. The topic of ABC in manufacturing and accounting has received a lot of attention.

On the other hand, ABC principles are rarely used in construction, it is based on the project work breakdown structure (WBS), which is shared by the estimate and schedule. Costs can be summarized by cost code, allowing accounting to use the same data.

Activity Based Cost Control involves recording the costs of various types of work like concrete casting, reinforcement, and formwork separately and on a periodic basis. The actual costs of these works are then recorded and analyzed to compare how well each activity performed in terms of cost against the budget.

Table 2. 3 Advantages and Disadvantages of Cost Control Tools and Techniques

Cost control Technique	Advantage	Disadvantage
Earned Value Control	- It is a powerful tool for measuring project performance, allowing the project team to track overall progress against planned progress. - It provides an early warning system for potential cost and schedule overruns enabling corrective actions. - It can identify the source of the budget and schedule overruns.	It can be complex and time-consuming to implement, requiring detailed planning, data gathering, and analysis. - It requires accurate and detailed data and may not be suitable for small or simple projects. - Earned value alone cannot provide insight into quality or risks.
Time cost Trade off	- It helps to optimize the use of limited resources, making it easier to complete projects within budget and time. - It allows the project team to flexibly allocate resources to the most critical tasks. - It can be useful for prioritizing project tasks.	The trade-offs may lead to compromises in quality or scope. - Decisions making can be subjective, leading to conflicts among project team members. - The approach may not be effective for projects with tight schedules and inflexible budgets.
Building information modeling (BIM)	- Provides a detailed digital model of all the elements of a construction project, allowing the project team to detect coordination issues. - Facilitates better communication within and between project teams & client. - The model can be reused and updated, reducing future costs.	- BIM requires a significant amount of initial investment in software, hardware, and training. - The model may not integrate well with 2D plans or paper documents. - The use of BIM may not be justified for small projects.
Forecasting	- Helps to anticipate potential problems and opportunities and enables the project team to take corrective actions before issues arise. - It enables the project team to visualize project's future performance and take corrective actions if needed. - Helps to set realistic goals and expectations.	- Forecasting is highly dependent on the quality and accuracy of the data used to make the forecasts. - It can be difficult to make accurate predictions for uncertain factors, such as weather changes, and economic factors. - Forecasts may not integrate easily with other project management tools or techniques.
Reserve analysis	- Helps to identify potential issues, which allows the project team to anticipate and plan for them. - Mitigates risks by setting cost and schedule allowances. - It can be easily integrated into other project management tools.	- Requires a significant amount of effort and resources to estimate contingencies. - Setting the right contingency can be subjective and uncertain, leading to overcompensation and unnecessary cost increases.

Cost control Technique	Advantage	Disadvantage
		- The project team may not always have accurate historical data to inform contingency estimates.
Activity based costing	• It maintains realistic field data collection. • It provides a method of categorizing costs by activity or by cost category. • It provides up-to-date information on activity status, enabling project personnel to quickly identify activities experiencing difficulty. • It provides a method of documenting changes to the work and distinguishing their quantities and costs from original contract items. • Standardization of codes enables comparisons to be made across projects, which are useful for future estimating purposes.	• Implementing activity-based construction cost control requires a high level of organization and attention to detail. • Project managers must be diligent in tracking costs, paperwork is bulky unless converted in to an IT system.

In this study, the selected technique for construction cost control is using the activity-based costing, one important benefit of activity-based cost control is that it helps project managers identify areas where costs can be reduced or managed more effectively. For example, if the cost of formwork is higher than expected, project managers can work to identify ways to reduce materials costs or find more efficient ways to complete the activity.

Another benefit of this approach is that it helps project managers identify potential problems early on in the project. By tracking costs and comparing them to expected costs, project managers can identify potential delays or other issues that could affect the project timeline or budget. In addition, it allows to have cost records, unlike other techniques it gives the performance of each activity in quantity and cost.

Implementing activity-based construction cost control requires a high level of organization and attention to detail. Project managers must be diligent in tracking costs, identifying potential problems, and working to implement cost-saving measures. For this reason, the study has incorporated a web-based application to the Activity Based Construction Cost Control to automate the process and avoid lots of paperwork. Therefore, by using this approach, project managers can gain better visibility into project costs, ensure that projects are completed on-time and within budget, and ultimately achieve greater success in the construction industry.

2.4.2 Relationship between Estimating, Budgeting and Controlling

In construction, cost estimation, budgeting, and cost control are essential components of project management. They are interconnected and work together to ensure successful completion of construction projects. Cost estimation involves forecasting the expected cost of the construction project from its start to completion. It helps in determining the project's feasibility and helps to allocate sufficient resources. Cost estimation usually includes factors such as labor cost, material cost, and revenue forecasts. It is essential to have accurate cost estimation to develop a realistic budget.

Furthermore, the final or detailed cost estimate is a starting point for evaluating the project's financial performance. Particulars from the detailed cost estimate are transformed into task cost components.

Project-specific work cost accounts are used to record expenses so that they can be compared to the initial cost estimates for each category. Individual job cost accounts are therefore typically the fundamental building block for cost control. Budgeting, on the other hand, is a financial plan that allocates resources and expenses to the different aspects of the project. It sets limits on expenditures and helps to measure the project's progress against the estimated cost. Budgeting plays a vital role in preventing expenditure exceedance and helps to control the project's unexpected costs. Cost control involves monitoring and controlling expenses to ensure they are within the approved budget. It involves regular review of project expenses against the projected cost. The primary goal of cost control is to identify fluctuations in project costs and their causes and take corrective measures to prevent cost overruns.

According to Hendrickson (2003), controlling project costs tries to limit changes to the project budget. Budgetary control uses the budget and budgetary reports to compare the actual results with the criteria set forth in the budget in order to identify the extent of variations, identifies the significant deviations' causes, and recommends measures. For cost control and monitoring reasons, the initial detailed cost estimate is frequently converted into a project budget. The project budget is then used as a management guide.

In conclusion, cost estimation, budgeting and cost control are essential components in construction management. Cost estimation helps to develop an accurate budget, and cost control ensures the project expenses remain within the budget. each of these components help to reduce risks and ensure a project is completed on time, within the budget, and to the desired quality.

2.5 **Project Resources and Controls**

Resources such as labour, materials, equipment, and money are inputs at the project site that result in outputs in the form of work. When controlling costs, the performance of these input resources determines whether a project succeeds (Hendrickson, 2008). Since delays are one of the main reasons for price increases, clients should take all reasonable precautions to prevent them.

2.5.1 Control of Material Cost

According to Orczyk (2018) a significant amount of material waste occurs on most construction sites for a variety of reasons. This waste can occur during the procurement process, during storage, and during use.

Waste that occurs during procurement may be the result of any one or more of the following factors: The following factors can contribute to wastage when purchasing materials with incorrect specifications, purchasing more than is necessary, purchasing short-life materials, and during storage: breaks and damages during handling, deterioration as a result of improper storage, poor maintenance, and short shelf life.

The majority of issues with material waste are related to ordering and requisitioning, receiving and inspecting supplier deliveries, handling and offloading, storing and protecting, and issuing, distributing, and using materials.

Among these the following are frequently cited causes for cost variances in construction materials management.

- Restocking fees
- Materials damaged on site.
- Loss of materials
- Late delivery of materials (impacts schedule)
- Unreported material damage at delivery
- Relocating materials
- Incorrect material take-off
- Changes of materials quantity required.
- Jobsite theft
- Uneconomic order quantity
- Material waste (over usage)
- Purchasing the wrong materials
- Excess site storage cost

Materials costs are determined as a combination of quantity, or consumption, and price. A material cost variation is brought on by a change in the price and/or quantity used. The quantity bought would match the amount called for by the design papers if there was no waste on the project. Although waste does happen, project management must make a concerted effort to reduce it.

- The following recommendations will assist project management in minimizing waste.
- Purchase correct quantities,
- Order optimal material sizes
- Verify quantities ordered, received, and billed,
- Verify quantities,
- Verify quantities billed,
- Protect materials on-site,
- Eliminate rework,

By supplying the required resources when and where they are required, material cost control aims to not only reduce the overall cost of materials but also boost worker productivity.

An accurate material take-off is required to purchase the correct quantities of material. The take-off required for the bid preparation is Costs associated with ordering too little material to complete the project include extra shipping charges and a lost quantity discount.

Additionally, one of the main reasons for lower labor productivity is running out of supplies. Restocking fees, higher inventory reduction (when materials are lost or damaged while being stored), and cash being held in inventory are all costs related to placing an order for too many things.

Additionally, the extra material will require unloading and reloading, which will raise labor and equipment expenses. On-site excess supplies will require regular removal and be vulnerable to theft and damage.

One more thing to keep in mind while buying the right number of materials, many builders store extra materials at the company storage yard. Before purchasing resources for your project, inspect the storage area. Purchasing supplies that your business has already purchased and kept is inefficient.

2.5.2 Control of Labor Cost

The amount of organization on the job site and the laborer's efficiency and effectiveness are both measured by the labor productivity attained at the site for a particular task. It displays the overall amount of time the worker was employed at work, the amount of time he or she was productive, and the amount of time the worker was not productive (Chikara, 2001).

The cost control process, according to Chitkara (2001), entails accounting for actual productivity, comparing it to the standard, understanding the causes of variances, and taking corrective action to improve, with a focus on the necessity of tight monitoring and a positive working environment.

Only when effective man hours are put in and targeted milestone dates are met will construction progress be achieved. Effective labor management can lower labor costs, increasing the company's profitability. Timecards can be used to track labor costs, which are challenging to manage.

The project's construction budget's most variable component is the cost of labor. Controlling labor costs is essential to the financial success of all contractors. Owners are also interested in keeping labor expenses under control for work done in-house and for work done by contractors who are paid on a reimbursement basis. In order to monitor actual labor cost performance and limit costs, project management must first create a realistic budget.

Efficiency and labor rates are two factors that affect labor costs. The many components of payroll burden that could result in budget variances are covered in labor rates in addition to wages.

The wage amount and the distribution of skilled, apprenticed, and unskilled labor among workers are factors that affect the average labor rate that estimators utilize. Numerous factors, which can be grouped into the following categories, affect labor efficiency, which is a measure of output to input:

1. Morale-related and motivational factors, such as the standard of management, supervision, communication, and information, as well as the degree of training, attendance, and the rewarding impact of changes.
2. Regional-such as the experience level of the workers, quantity and quality of labor supply, and local customs such as coffee breaks.
3. Considerations for work scheduling and planning include the accuracy of deadlines and schedules, the utilization of overtime and shiftwork, the order of tasks, and material flow. If the ratio of trainees to professionals is not optimal, the skilled mix has an impact on efficiency.
4. Environmental and climatic conditions.
5. Job characteristics-such as the size of project, complexity, and repetitiveness.
6. Changes-as they affect job rhythm, disruptions, and acceleration.

These categories of factors are not intended to be exhaustive, but they do show the many factors that could impact labor efficiency and contribute to variances.

2.5.3 Control of Equipment Cost

The choice and use of equipment in a project must be a crucial component of the overall plan. The kind and quantity of equipment needed for any project depends on its nature. It has a considerable impact on construction costs. Construction equipment is difficult to regulate owing to unpredictable costs, however it may be tracked using timecards just like labor costs (Orczyk,2018).

2.6 Cost Control Techniques Used by Contractors

Research done by Owale and Sun (2010) in UK (United Kingdom) on Construction Project Control Current Practice, Existing Problems and Recommendations for Future Improvement based on a questionnaire survey was carried out in 250 top companies in UK to establish the current practice and identify existing problems.

The most practiced cost control techniques by contractors and consultants are project cost value reconciliation, overall profit and loss, profit or loss on each contract at valuation dates, unit costing, earned value analysis and program evaluation and review techniques.

In addition, the study had in-depth interviews with 15 experienced practitioners from companies to have further insights into the problems. The study revealed that during cost control the monitoring, the management in places doesn't seem strong enough because quite often monitoring does not follow a periodic management nor utilize a dedicated structure such as computer systems or templates (Owale and Sun, 2010).

A study by Chibueze et al. (2018) on application of project management control mechanisms in construction projects: a case of port Harcourt, rivers state, Nigeria. The study deployed survey and exploratory research design methods of investigation, while a convenient/purposive sampling technique was adopted in selecting the sample size of 96 respondents from a population of 143 respondents. The earned value management is the most frequently applied/used project management control mechanism with a relative importance index (RII) score of 0.20 and was ranked first. This is followed by the use of Milestone with RII score of 0.19, Time-cost trade off analysis with RII of 0.18, location-based management system 0.17 and finally building information modelling system, 0.16.

2.6.1 The Practice of Cost Control in Ethiopian Construction Industry

Regarding cost control in Ethiopian construction research by Hiwot (2011) on the project management control practice in grade one building and general contractors in Addis Ababa reveled that the most practiced cost control techniques by Ethiopian contractors are stated in rank from highest to lowest are performance review, forecasting technique, reserve analysis, EVM and to complete performance index TCPI.

Forecasting

Forecasting uses the information that is gathered performance of the project based on what is known when the calculation is performed. Forecasts are based on work performance information (an output from the executing process group) and predictions of future performance. Forecasts are generated, updated, and reissued based on work performance data that is provided while the project is being executed. The work performance information covers the projects project in the future.

Performance Reviews

Reviews of performance compare the costs over time, the activities or work packages that go over or under budget, and the anticipated money required to finish the current task.

Reserve Analysis

Reserve analysis is used to monitor the state of the project's management and contingency reserves during cost control in order to ascertain whether these reserves are still required or whether more reserves should be requested. These funds may be used as intended as the project moves forward to pay for risk mitigation activities or other unforeseen expenses. To free up funds for other projects or activities, the unused contingency reserves could also be removed from the project budget if the likely risk events don't materialize (PMI, 2004).

To-complete Performance Index (TCPI)

The to-complete performance index (TCPI) is a measure of the cost performance that is required to be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the remaining budget. However, the researcher did not discuss the extent or the detail use of these techniques by the sampled contractors.

According to Abselom (2008) and Taddesse (2006) the most practiced cost control technique is Earned Value Management in Ethiopian construction industry. However, the problem with using this technique is the data collection as well as analysis is not regularly done, and an organized database system is also not in place.

There is limited research about the cost control in construction projects in Ethiopia to show the practices and extents. The measurement of project performance is essential as it enables important management decisions to be reached on time and also helps in identifying areas requiring improvement.

Overall, there is no single cost control tool or technique that will suit every construction project. The key is to understand the advantages and disadvantages of each tool and select the most appropriate one based on the project's unique needs and constraints.
In this study however the selected technique for construction cost control is Activity-Based Costing because of the multiple benefits it possesses, an Activity-Based Cost control,

- Helps project managers identify areas where costs can be reduced or managed more effectively.
- Helps project managers identify potential problems early on in the project. By tracking costs and comparing them to expected costs, project managers can identify potential delays or other issues that could affect the project timeline or budget.
- It allows us to have cost records, unlike other techniques it gives the performance of each activity in quantity and cost.

According to Fayak (2001), There are a number of advantages associated with the Activity-Based costing approach including the following,

• It maintains realistic field data collection requirements and suits the way in which actual costs and quantities are collected in the field.

• It provides a method of categorizing costs by activity or by cost category, providing useful information for future estimating purposes. Information on the actual productivity and cost of individual activities can be easily determined using this approach.

• It provides up-to-date information on activity status, enabling project personnel to quickly identify activities experiencing difficulty at any stage of their completion so that timely corrective actions can be implemented.

• It provides a method of documenting changes to the work and distinguishing their quantities and costs from original contract items. The ability to standardize activity codes and cost codes also provides several advantages.

• The many-to-many relationship between activity codes and cost codes yields a system with extensive flexibility to suit most projects.

• Standardization of codes enables comparisons to be made across projects, which are useful for future estimating purposes as well.

• The ability to incorporate any set of standard cost codes, such as Master Format, provides a natural link to existing accounting practices.

Implementing Activity-Based Construction Cost control requires a high level of organization and attention to detail. Project managers must be diligent in tracking costs, identifying potential problems, and working to implement cost-saving measures. For this reason, the study has incorporated a web-based application to the Activity Based Construction Cost Control to automate the process and avoid lots of paperwork. Therefore, by using this approach, project managers can gain better visibility into project costs, ensure that projects are completed on-time and within budget, and ultimately achieve greater success in the construction industry.

2.6.1.1 Challenges of Cost Estimation

Tadesse (2006) asserts that Ethiopia's construction sector lacks both organized database system and experienced estimators. According to the survey done by the researcher, a lot of contractors employ unit pricing that has already been developed by rival contractors they consider to be well-organized without explaining the cost elements that make up these unit prices.

The research goes on to say that project owners anticipate contractors to submit bids for jobs that will be completed quickly and to a high standard. Naturally, the contractor must present the lowest construction cost in order to win the bid. In light of the current unfair market competition, there is a significant tendency to undervalue one's ability to continue doing business.

Abeselom (2008), For determining contract prices, contractors frequently use the standard or detailed estimating method. A significant amount of information on resource costs, consumption and production standards, as well as other qualitative items, must be gathered, collected, and modified in order to prepare such a precise estimate.

Major factors affecting the accuracy of contractors' cost estimates have also been identified by the researcher, which include:

- unfamiliarity with various estimating methodologies.
- a lack of current estimating manuals.
- an insufficient search for information on project-specific and contextual cost and non-cost items.
- improper estimation of overhead costs.
- failures to evaluate and incorporate; and/or challenges in forecasting quantifying risk allowances.
- Inadequate consideration of all relevant variables when calculating markup or profit margin

2.6.2 Challenges of Cost Control

According to Abselom (2008) most contractors only collect data on profitability as part of their cost control efforts. In addition, the cost estimation procedure does not offer insight into how to value or price future bids. Giving input to the estimation process is one of a cost-controlling system's main goals. Setting up a database or cost records that keep track of actual production costs and productivity standards makes this easier. And this leads to the Ethiopian construction, to typically move from proactive cost estimating to reactive cost control of any changes in the work.

According to Nega (2008) "Many aspects in construction process remain uncertain and normal costing practice shall include an extra element to provide "insurance" against cost overruns. The word "contingency" is usually used to describe this additional cost element. The contingency is typically based on a "rule of thumb" calculation, as a certain percentage of the estimated cost. A figure of 10% of gross costs is a common allowance. The use of a better specified contingency will only be effective if suitable project control procedures are in place to control all aspects of project performance. However, it should be noted that improved contingency planning can never be a substitute for good project cost management" (p.65).

It is inevitable changes arise from a number of different sources, unforeseen conditions, owner generated changes, drawing errors and omissions, code issues or contractual claims, etc. so, an efficient cost-controlling system will update resource planning and costing standards, provides data that can increase resource output, and provide early warning of unprofitable operations. (Tadesse, 2006 and Nega, 2008). Generally, while cost control tools and techniques can be very beneficial to the construction industry, they are not without their challenges. It's important to carefully assess whether your project requires the implementation of such tools and techniques.

1. **Implementation Challenges**

Implementing cost control tools is a time-consuming process, which requires significant planning and investment in infrastructure and personnel training.

2. **High Initial Investment**

Some cost control tools have a high initial investment which may make it difficult for small companies to invest in these tools.

3. **Inaccuracies**

Cost control tools are only as accurate as the data inputted into the system. Any mistakes in data entry or missed steps can lead to inaccuracies in reporting and decision-making.

4. **Resistance to change**

New tools and techniques may disrupt the traditional work process of the managers and employees, triggering a resistance to change.

2.7 Research Gap

The most problematic issue in Ethiopian construction industry is that cost control has not been given much emphasis as to estimation and budgeting however, it is the cost control method that will help the cost estimation to become a better estimation with time and information regarding the project performance.

A good organization cost database serves as the only foundation for accurate project cost estimations as well as the performance evaluation of project execution during construction this will enable to give feedback on real productivity standards and production costs to the estimation process so that time and cost behavior can be understood.

In addition, the cost accounting and controlling methods are not operating in real-time, due to the absence of the cost database system which mainly leads to the management failing to measure the project performance accurately and makes uninformed decisions.

Hendrickson (2003) states the accuracy of the initial estimate and the effectiveness of the cost-controlling method have an impact on the gross profit made by contractors after projects are completed. The main barriers identified that are preventing contractors from maintaining a healthy cash flow and securing the expected profit amount from projects are inaccurate cost estimates, inadequate accounting records, and ineffective cost-controlling practices.

There is a substantial amount of literature on the subject of ABC in accounting and manufacturing. The ABC principles, on the other hand, are rarely used in construction, there is no prior research for applying this costing system for construction projects in Ethiopia. Finding the cause of the variance, estimating its size, and deciding whether corrective action is necessary are all crucial components of cost control.

Activity based construction cost control is a powerful tool that can help project managers keep track of construction costs and ensure that projects are completed on-time and within budget. This method of cost control uses a variety of activities to break down the costs associated with a project and identify areas where costs can be reduced or managed more effectively.

The first step in Activity-Based cost control is to identify the activities associated with each phase of the construction project. This can include everything from site preparation and excavation to foundation pouring, framing, roofing, electrical work, plumbing, and interior finishing. By breaking down the project into these smaller activities, project managers can more easily track costs and identify areas where expenses are higher than expected.

Once each activity has been identified, project managers can assign costs to each, including manpower costs, materials costs, equipment costs, and any other expenses associated with the activity. This provides a detailed cost breakdown that can be used to track costs throughout the project.

The important benefit of Activity-Based cost control is that it helps project managers identify areas where costs can be reduced or managed more effectively. For example, if the cost of formwork is higher than expected, project managers can work to identify ways to reduce materials costs or find more efficient ways to complete the activity.
Activity Based cost control will allow the construction projects to have data of cost records, which will help for cost controlling, give feedback for valuation for subsequent bids, and to get productivity and production standards.

Unlike previous research's, this Activity-Based approach to cost control and the corresponding reports described in this thesis aims to be converted into an automated data acquisition and

reporting system. The field data acquisition will be collected by hand, a central database would receive field data on a daily basis, from which up-to-date cost controlling reports can be automatically generated. Multi-user access and data synchronization are essential to enable field data to be incorporated and to be used to update job costing reports and to enable these reports to be viewed instantaneously in the office anywhere at any time.

CHAPTER 3 METHODOLOGY

3.1 General

This study aims to develop a Web- based Activity-Based Cost Control System to address issues regarding the challenges of cost control in building projects by contractors. The study strives to develop a software-based application that manages to control and have real time data of the actual construction costs in building projects.

3.2 Research Design

The study begins with a detailed study of literature to gain a thorough understanding of the current construction cost control processes and techniques used in practice. This will be essential in the development process to identify all the variables and relations that should be analyzed in the system.

In this study the selected technique for construction cost control is using the activity-based costing, one important benefit of activity-based cost control is that it helps project managers identify areas where costs can be reduced or managed more effectively.

Another benefit of this approach is that it helps project managers identify potential problems early on in the project. By tracking costs and comparing them to expected costs, project managers can identify potential delays or other issues that could affect the project timeline or budget. In addition, it allows to have cost records, unlike other techniques it gives the performance of each activity in quantity and cost.

However, this cost control technique is developed as a web based application rather than an excel template because web-based applications are typically more robust and are designed to handle more complex processes. They can be accessed from anywhere with an internet connection and can be customized to meet specific requirements. Moreover, it allows team members to work together on tasks, set deadlines, and monitor progress in real-time.

On the other hand, Excel templates are generally simpler to use and do not require specialized training. They are self-contained files that allow users to perform basic calculations and data analysis. They can be customized by adding formulas and functions, but their functionality is limited compared to web-based applications. Excel templates cannot be accessed at anywhere, if changes are made, they cannot be easily tracked and are vulnerable to the file being missed or deleted, they are composed of multiple pages accessing and understanding will be difficult.

The study will develop a web-based application based on the Activity-Based cost approach as shown in the flow chart below in figure 3.1. The approach to the solution for the problem statement is systematically tracked based on literature reviews of local and international research to design an Activity Based cost control system that will address the limitation and challenges of current cost control system. In addition, real time data from selected case studies is used, the case studies real time data will be collected by observation and recording on a paper format that is exactly the same to that of the data entry system the web application this will help for validation and verification of the web-based application, further the data collected from the project sites is analyzed in the web-based application through reports to analyze the actual costs of activities and compare them to the budgeted costs.

This web-based Activity Based Costing for building construction projects will minimize time, reduce error and create a secure and easily accessible database system.

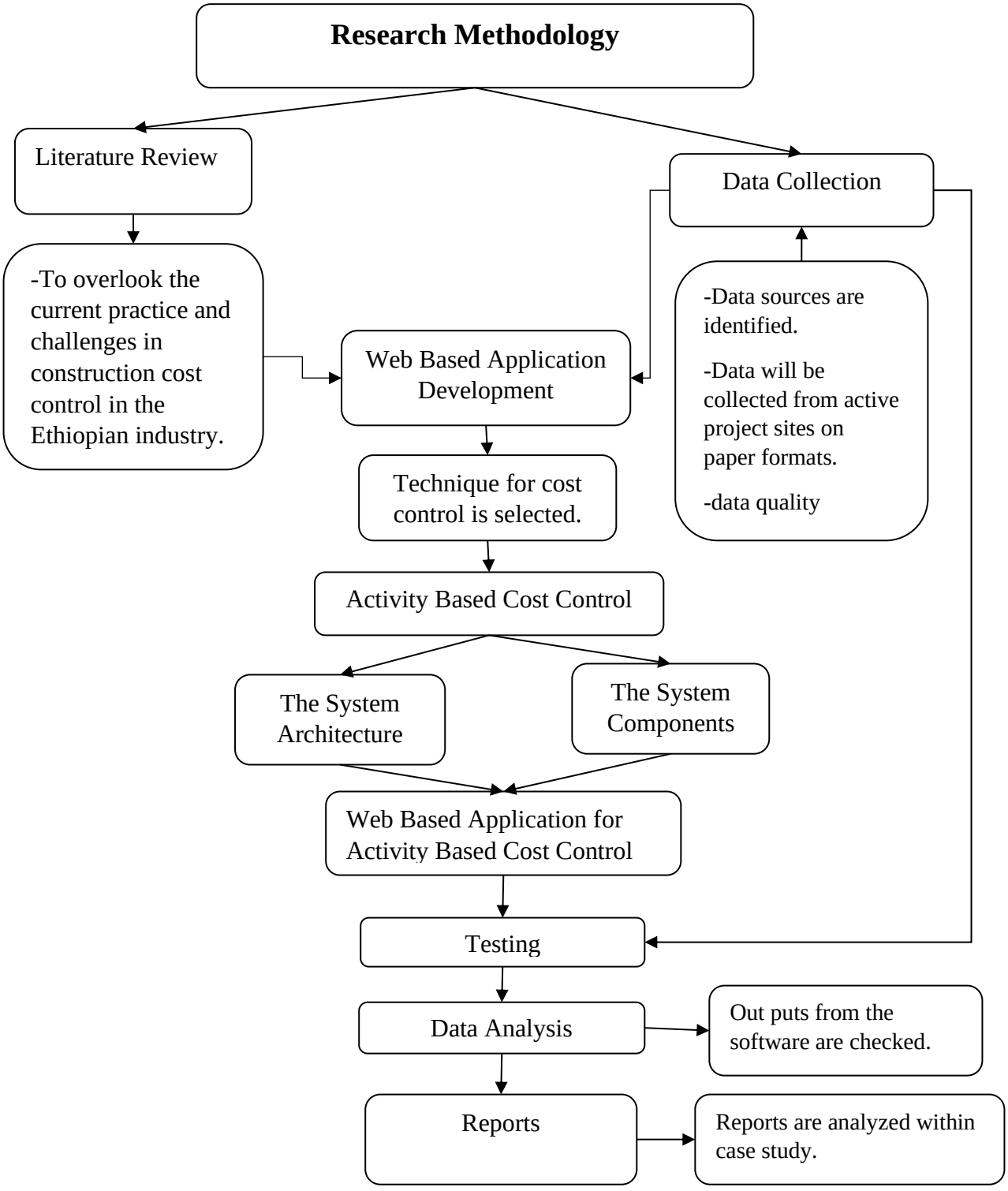


Figure 3. 1 Research Methodology Flowchart

3.3 Research Method

There are different research methods based on the research philosophical background. The common ones are experiments, surveys, case study, ground theory, action research and ethnography. In selecting the right research method, one has to consider the purpose of the research, nature of the research problem, the type of data needed and researchers' ontological and epistemological assumptions on the problem of the research. As it can be seen from previous discussions, the nature of the research problem and the research objectives stated earlier, this research is action research through case studies. T

Single case studies are used for validation and verification of the web-based application and further the data collected from the project sites is analyzed in the web-based application, from the reports of each project site got from the web-based application within single case analysis will be presented. These will help project managers to identify areas where costs can be reduced or managed more effectively. For example, if the cost of formwork is higher than expected, project managers can work to identify ways to reduce materials costs or find more efficient ways to complete the activity.

According to Zegeye et al. (2009) the primary purpose of action research is discovering, interpreting and the development of methods and systems for solving practical problems on a wide variety of real-life situations of our world and the universe.

Action research:

- Is conducted in relation to actual problems and under the conditions in which they are found in practice.
- Employs methodology that is not as rigorous as that of basic research.
- Yields findings that can be evaluated in terms of local applicability and not in terms of universal validity.

3.4 Case Sampling

3.4.1 Determining the Case Design

According to Yin (2003), there are two major types of designs in the case study, single case design and multiple case study design. A single case study design focuses only on one case while in multiple case study design cases should be selected so that they are replicating each other either exact (direct) replications or predictably different (systematic) replications.

Some of the rationales for using in single cases is when it represents the critical case in testing well formulated theory, in cases representing an extreme case or unique case, single case is the representative or typical case, revelatory case and in case of longitudinal cases; whereas the major insight to consider multiple is to follow a replication logic. In this logic each case must be selected as it needs to predict similar results or predicts contrasting results for predictable reasons (Yin 2003).

In this study, single case design is selected for collecting data, from three different contractors in different sectors as the subject under study involves using real time data to know the actual cost information, which enables to have project specific cost information by unique case.

3.4.2 Techniques for Case Selection

The study has used nonrandom purposive sampling. Data will be collected from three projects that are grade one local building contractors and from different sectors in Addis Ababa. Observation technique will be used to collect raw data from these construction project sites based on activities on going, and then the data will be fed to the web-based application that will be developed, this web-based application creates relations by automating the whole cost control process to minimize time, reduce error and create a secure and easily accessible database system.

Due to time and financial constraint the study includes only one project site data from each of these three projects, and the daily cost information gathered from these project sites is for a month from the projects. The projects are selected based on specific merits they exhibit that are necessary for the implementation of the study.

Projects were selected based on the following merits.

- The projects should be active or ongoing.
- Project must be contracted with Grade one local building contractor.
- Willingness to provide the project information, cost information and engineering estimates.
- Projects that use Unit priced contract (re-measurement contract).
- Each project is from a different sector.
- The status of projects should be at early stages so the outcome of the study will help show the projects performance.
- Projects are relatively large projects.
- The data and analysis learned these sample projects and the cost control approach can be used for similar projects and for those in lower grade contractors.

3.5 The Data Collection Technique

The main source of data for this research will be collected through observation techniques because it is reliable, and a real time data is needed from the ongoing construction projects to determine the actual cost of activities. The research will use the project's daily cost information based of activities on WBS as a source of data for the web-based application from each case.

The study proposes a framework to automate a web-based cost control mechanism in building construction projects by using an activity.

Being a web-based application will help to have access to timely information on project status at any given point in a project, to reduce the amount of paperwork and handling of data and cost information; and, to develop better reporting method that helps the management to make more informed business decisions.

The first step is to prepare a field data cost information acquisition, this is applied in formats that includes the daily ongoing activities, of which the activities material quantities used, costs of materials, daily labor costs and crew compositions for an activity, daily wages of labor, equipment types and daily rental costs and subcontracting costs as well are included.

Field Cost Data Acquisition Formats

The field data acquisition formats include the following and are prepared first in excel by referring to different literatures.

• Daily site forms for collecting labor, material, equipment, and subcontractor quantities and costs.

Daily Site Forms: Figure 3.1 and Figure 3.2 shows daily site form for labor data and material data respectively. A similar format can be used for collecting data for equipment, and subcontractors. These forms can be modified to collect other relevant information's as well.

Date	Activity Location	Activity Name	Unit	Executed Quantity	Actual Labor cost									
					Crew members	Quantity Man Power	U/F	Morning	Afternoon	OT	Working Hr.	Indexed Actual labor cost Per Hr.	Indexed Actual labor cost Per Day	Labor Unit cost

Figure 3. 2 Daily site form for Labor

Date	Activity Location	Activity Name	Unit	Executed Quantity	Actual Material cost					
					Description	Unit	Actual Qty. required (Qty*)	Unit price	Actual Material cost	Material unit Cost

Figure 3. 3 Daily site form for material information

Figure 3.2 shows the daily site form for collecting labor cost information for each activity and sub activity on site. Information's such as crew composition, quantity, labor hour and daily cost are included.

Figure 3.3 shows the daily site form for material cost and includes information's such as the actual material used to execute an activity and information's such the unit cost of these materials.

However, the unit prices of materials supplied from the local market or produced on-site, the material unit price includes the cost of loading, unloading, and transportation costs to the project. If the material is imported from another country, the price includes the logistics of imported materials as well as international commercial terms and includes these additional costs. The material unit price in this study is the material unit price at the project site.

3.6 The Web Application System Development

Designing the system architecture and creating the system components make up the two parts of system development. The system architecture will list the interdependencies between the database, backend, and frontend components of this system (Perry and Wolf, 1992).

Additionally, it offers a structural representation of the finished system. The five subsystems that make the web-based application work here are explained in the system components. Below, we'll talk about these components' specifics.

3.6.1 System Architecture

The software will be a web-based application that has both backend and frontend. The reason for choosing a web-based application is that it allows users access to the system from anywhere and at any time.

Additionally, users can share their work and real-time update is also possible. Front-end refers to the user interface where users interact with the software. Back-end refers to the server that provides data to the user when requested. The core concern of back-end development is creating applications that can find and deliver data to the front end. The front end is built to be user-friendly and interactive.

The languages used are Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), React.js and JavaScript. The server and database communicate with each other through the back end developed.

Components for Frontend

- HTML
- CSS
- React.js

- **HTML** stands for Hyper Text Markup Language. HTML is the standard markup language for creating Web pages. HTML describes the structure of a Web page. HTML consists of a series of elements. HTML elements tell the browser how to display the content.
- **CSS** (**Cascading Style Sheets**) is used to style and layout web pages — for example, to alter the font, color, size, and spacing of your content, split it into multiple columns, or add animations and other decorative features.
- **React.js** framework is an open-source JavaScript framework and library developed by Facebook. It's used for building interactive user interfaces and web applications quickly and efficiently with significantly less code than you would with vanilla JavaScript.

Components for Backend

- Java EE Hibernate
- MySQL
- Database

- **Java EE Hibernate** When you are developing a web or a desktop application, it could be cumbersome and time-consuming to work with **Java Objects** and **Relational Databases Tables.** This is due to the paradigm mismatch between how

data is described in objects versus relational databases. **Hibernate** is an open-source framework that manages the persistence of objects in a relational database. It also offers an *Object/Relational Mapping* solution for **Java** environments. *Object/Relational Mapping* refers to a technique that consists of mapping data from an object model representation to a relational data model representation (And vice versa).

- **MySQL** is a tool used to manage databases and servers, so while it's not a database, it's widely used in relation to manage and organizing data in databases.
  Database is an organized collection of structured information, or data, typically stored electronically in a computer system. A database is usually controlled by a database management system (DBMS).

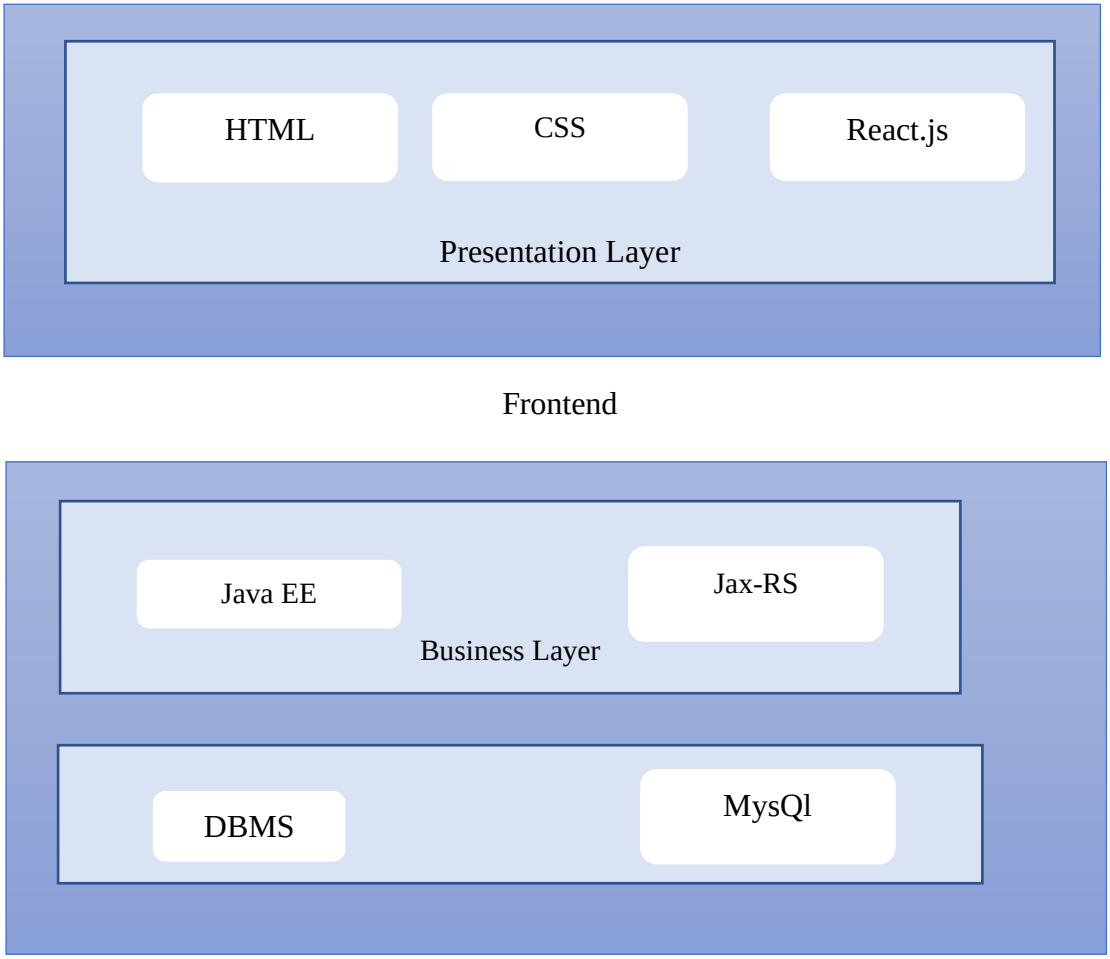


Figure 3. 4 Technology Module

3.6.2 The System Components

The system development process consists of creating five subsystems namely: -

- Project information interface
- Raw data entry sub system
- Cost data processing sub system
- Cost reporting sub system
- Security

3.6.2.1 The Project Interface Subsystem

This is the first subsystem that will be developed using JavaScript and it will allow the users to create, update, add, delete, view the projects, activities, and sub activities in the WBS. In addition, it helps to create activities and sub activities with their budgeted costs and unit rates. These will be integrated with the security subsystem to make it secure and harmonious.

3.6.2.2 The Raw Data Entry Subsystem

In the raw data entry sub system, the system will be created and designed to suit and look like the paper format and will allow to directly be entered by the personnel into the system from the paper. An excel format is prepared based on different literature reviews prior to the design of the web application to fit the same information into the system. In this sub system the user will be allowed to first select the activity then the sub activity with its cost code, after that the system automatically gives a page where the sub activities daily cost information can be entered. The cost information page includes the daily executed quantities of activities, their labor, material, equipment cost on daily basis and subcontract cost if it has any.

3.6.2.3 Cost Data Processing Subsystem

These subsystems will greatly aid the contractor by keeping track of all information related to the activities' direct costs and giving the actual direct costs and cost performances of each activity. Here all data will be time- related and categorized based on sub activities and cost codes. Only the direct cost is considered in this thesis and the indirect cost will be the percentage set by the grade one contractor so, the total cost will be the sum of the actual direct cost and the percentage set by the contractor for the indirect cost. for example, if the indirect cost is 35 % of the direct cost, the system will add automatically the 35% percent to the actual direct cost to compare it to the budgeted cost. Furthermore, the user will be given the option of setting cost information's based on each activity on site, such as the daily unit prices of materials (purchased and arrived on site), daily labor costs, equipment daily rentals and subcontract costs if any.

3.6.2.4 Cost Reporting Subsystem

The report contents and formats will be defined ahead of time from different literatures and after discussion with the contractor. The reporting system will be integrated with the other subsystem to create a standard, relevant and timely report of the actual cost information's based on activities.

3.6.2.5 Security Subsystem

The database should be secure enough to provide the contractor's cost information's therefore, a security system, that follows an organizational hierarchy will be adopted. The users will have a username and password to access the database. Accessibility will be for data entry personnel only for some users and with the ability to modify and certify for others. The system will provide an option to save and send the daily field data on costs of activities entered by the personnel/ data collector and after, it will be certified by the privileged user. Finally, all these subsystems will be integrated and tested with data from multiple projects. Errors in the system that could potentially occur will be collected. Based on the error reports and feedback from the trials the integrated system will be reassessed and once all bugs are fixed and fully functional.

The data gathered through observation technique as stated earlier includes all the necessary information about the daily labor cost, crew quantity, utilization factor and indexed labor cost per day, the material format also collects the quantity of material used to accomplish a specific activity and its unit cost arriving on site in each time frame, the equipment format also collects information's such as daily rental cost, its utilization of equipment for a specific activity and quantity of used will be recorded. Any other useful cost information can also be collected by

using this format. Regarding data collection in this study, the first step is to create the checklist for data collection and validation. A detailed analysis on the raw data collected from the site, was performed to identify, evaluate, and approve the data. All the data must meet the following quality attributes presented in Table 3.1 below.

Table 3. 1 Data Quality Attributes

Quality Attribute	Details of the attribute
Data Accuracy	➢ Manually cross checking the input raw data and the data entered in the web application software. ➢ Athematic check of daily reports. ➢ Supervising the collected cost information's continuously. ➢ Checking on previous cost information data with today's collection.
Data Completeness	➢ Checking all field acquisition forms are filled properly. ➢ Items of materials of each activity, equipment's used, material cost information's with their unit prices and crew compositions are filled realistically and correctly.
Consistency	➢ Checking field acquisition forms and daily site diaries to see if they match in different aspects. ➢ Previous records of data match or not.
Timeliness	➢ Checking the time records of the field reports since the study proses a daily acquisition of the data the working and non-working days are filled properly.
Relevancy	➢ Checking if the cost information gathered is important to the activity.
Auditable	➢ Checking if the real time data is also accessible since the raw data will be collected in paper. ➢ Checking if changes can be traced, errors can be tracked

The above process shows how the data quality is validated using manual procedures. Additionally, the system has its internal data quality checking mechanism. This mechanism is dependent on specified data quality attributes coded into the system. The quality attributes and their detail are presented in Table 3.2 below.

Table 3. 2 System Data Quality Attributes

Quality Attribute	Details of Attribute
Data Type	Integer, float, string
Date Format	Fixed format and directly picked from the application (DD-MM-YYYY)
Range	Specified range (below 100)
Consistence expressions	Sequence between data

The system checks all data as the user enters them based on this mechanism and displays nothing if it does not correspond to its standard. The validation process will comply with established standards for software validation like IEEE SA - P1012. The validation process follows common procedure that will make sure that the software developed performs as per the intended use. The system requirements and conditions are outlined. The system will be designed to run on any web browsers including Microsoft Edge, Google Chrome, Mozilla Firefox, and Opera. Multiple users will be created with unique username and password to test the capacity of the project interface to allow real-time collaboration and integration. The manual prepared excel format will be used to compare the system output with the cost information processing. The system's data processing efficiency, precision, and error reporting will all be closely examined. Every step is carried out again for the data from each project. This procedure is intended to find system flaws or limitations. On the basis of this, a conclusion can be made.

CHAPTER 4 ANALYSIS AND DISCUSSION

4.1 General

Based on the method presented in the methodology section and literature review, this chapter provides the overall discussion and analysis of the research results. In the first part, it includes the designing and the software development process. In the second part, it covers data collection, such that the cost information based on activities in the WBS. In the third part, it presents how the input data in the developed software are entered and analyzed. Finally, the software output data resulting from the inputs i.e., actual direct costs, performance reports and the key research findings are discussed.

4.2 Development of Web-Based Activity Based Cost Control

4.2.1 Web based Activity Based Cost Control

The Activity-Based Cost control in this research is cost accounting for the various types of work, such as concrete casting, reinforcement, and formwork recorded separately and periodically, and then the actual costs of these works are recorded and analyzed to compare to the budgeted cost. The logic for the activity-based cost control is created by the activities in the WBS, since each activity consumes resources, which carry costs. The activity-based approach to cost control requires that costs be recorded against the lowest level activities in the project WBS (i.e., at the task level). Costs are coded against cost codes (which represent tasks) combined with activity then the actual costs of activities are tracked and analyzed.

To accomplish this, costs have to be linked to particular on-site operations and recorded against cost codes on daily reports. The foundation of activity-based job costing is the reporting of costs against activities and the standard cost codes used in accounting-based cost control. It reflects how costs are tracked in the field on a regular basis. cost codes are used to represent the activities included in the estimate and schedule and act as a connection between these functions (Fayak,2001).

Work Break Down Structure

The relationship between each project component and the project outputs is provided by the works breakdown structure (WBS) for the project. The project breakdown procedure allows the division of the project work into hierarchical work-breakdown levels, each of which represents a distinct task that requires time and resources. An activity is a resource- and time-consuming component of a project that is typically specified for time and cost control by a planner, estimator, scheduler, or cost engineer. An activity is typically connected to the production of a visible component of the desired finished output. Generally speaking, work packages or tasks should be used as a common data source for the purposes of project planning, estimating, monitoring, and controlling. Resource forecasts can be created using the labor, material, and equipment inputs required to carry out each task.

Codification in Construction Projects

A construction job involves a variety of work categories. A pre-defined code unique to that activity would be used to identify each activity or category of work that was specified for a project. Additionally, materials, labor, equipment, and other estimate are required for each project action. In order to create a plan that separates those descriptions and costs, it is crucial to maintain some level of order. Ostwald (2001) asserts that coding, a form of classification, has an advantage in estimate preparation, cost control and assurance, and data management.

Ostwald added that codes serve as the link between planning, budgeting, purchasing, scheduling, cost controlling, and accounting.

Coding systems are adopted to provide a numbering system to replace verbal descriptions of items. These codes reduce the length or complexity of the information to be recorded. Common coding systems also aid in the retrieval of historical records of cost productivity and duration on activities. According to Pierce (2006) a system for dividing the numbers into meaningful groups should exist; the coding system does just that. While there isn't a single, universally accepted project cost coding system, most numbering systems do, in fact, include all or most of the following components.

Project number: Typically, the project number relates to a particular deal that the business has taken on. Along with the project number, a code for the project's area or location, job type, or another sub-classification may be given.

Work type: In terms of precise project cost management, this is likely the most crucial section of the code. This number is used on the work to differentiate between various materials and trades.

These cost codes are directly adapted from the master format, the Master Format is a standardized arrangement of work in North America and Canada made by the Construction Specifications Institute of Canada and the Construction Specifications Institute of the United States, where these codes are used to provide to enhance the speed and quality of communication by professionals participating as part of a construction project team.

Though it was designed initially for use in commercial and institutional building construction, it has been expanded to fully address the needs of heavy civil, roadway, process, and industrial construction projects indeed, Master Format can now be used for any type of construction in which humans engage.

The Ethiopian ministry of construction has also a similar standard which is called the Ethiopian Construction Practice Norms Compulsory Standard CS-167 and CS-168, this standard is a Standard Method of Measurement that forms part of contract documents that govern the construction of buildings.

This standard is used for the preparation and implementation of residential, commercial, civil, and industrial constructions. It categorizes works in divisions and codes that must be used as a standard of practice in construction works.

The use of cost codes provides a simple, yet effective, method of integrating the four functions of estimating, scheduling, job costing, and accounting. Therefore, in this research cost codes are adapted from Ethiopian Construction Practice Norms Compulsory Standard together with the master format approach (Fayak,2001).

Costs are recorded against the lowest level activities in the project WBS when using an activity-based approach to job costing (i.e., at the task level). Cost codes (which represent tasks) are combined with activity codes to create a unique code for each task. The lowest level activities (i.e., tasks) in the WBS can be represented using traditional accounting cost codes, such as the Master format or the Ethiopian standard way of measurement (Fayak,2001).

Cost codes should be representative of actual on-site activities and at a level of detail that allows for cost reporting and tracking. A strong difference between cost codes is necessary to ensure that each expense has a well-defined category and that costs cannot be assigned to more than one category; the cost codes should cover all parts of the task.

The activity-based approach to job costing proposed in this thesis treats the cost codes from Master Format and the Ethiopian standard cs 167 and 168 as tasks in the WBS (i.e., activities at the lowest level in the WBS). Therefore, it does not impose additional nor unrealistic data collection requirements. Furthermore, it operates based on the project WBS, which is shared by the estimate and the schedule.

The Ethiopian standard CS 167 and 168 involves a hierarchical coding system with multiple levels and key work text descriptions of each item.

Table 4. 1 Major divisions in the Ethiopian standard CS 167 and 168.

Division		Division	
01	Preliminaries	10	Specialties
02	Existing conditions	22	Plumbing
03	Concrete	23	Heating, ventilation & air-conditioning
04	Masonry	26	Electrical
05	Metal work	27	Communication
06	Wood, plastic, and composite's	28	Electronic Safety and security
07	Thermal & moisture protection	31	Earthwork
08	Openings	32	Exterior improvements
09	Finishes		

The first two digits in the numerical coding scheme stand for one of the 17 job divisions. In the latest version, each division has Six-digit numbering system that is defined and designated for a definite purpose. For example, Subdivisions of Division 03 (Concrete) of the Ethiopian standard CS 167 and 168 The codes that can offer a thorough understanding of the classification system are shown below.

DIVISION 03 – CONCRETE

Section Number and Title

031100 Concrete Formwork

032100 Steel Concrete Reinforcement

033000 Cast-In-Place Concrete

034100 Structural Precast Concrete

034133 Precast Pre-stressed Concrete

Each project will have a list of activity codes and a list of cost codes, with these two lists having a many-to-many link (i.e., an activity code can have more than one cost code associated with it, and a cost code can have more than one activity code associated with it).

The list of cost codes does not grow when there are an increasing number of activities because the same cost code can be applied to any number of activity codes. To compare actual costs, productivity, and other metrics across projects, there should ideally be a uniform set of activity codes and a common list of cost codes for all projects (Fayak,2001).

The benefit of this system is that the quantity done for each activity can be correctly measured and related to the expenditure incurred thus far. Site staff will report the quantity completed for each activity, as well as each cost code, at the end of each reporting period. If the quantity complete was only reported against each activity on the project, it would be difficult to identify

which elements of the activity had been completed (rather than splitting the activity down into its cost codes).

In this research the web-based activity-based costing considers only the costs of different kinds of activities, such concrete casting, and will be tracked separately under this system. The costs are divided by the volume of each sort of work, both cumulatively and periodically. Consequently, unit costs that can be compared to those predicted in the tender provided. Generally speaking, work packages or tasks should be used as a common data source for the purposes of project planning, estimating, monitoring, and controlling. Resource forecasts can be created using the labor, material, and equipment inputs required to carry out each task. For the work packages as well as the overall project, the activity cost is used to calculate the income and cash-flow forecasts. For tracking the progress of the project task, the activity base is essential.

4.2.2 Description of input and output parameters

In put parameters

- Activity and sub activities details based on the work break down structure, the system automatically gives cost codes for the sub activities using the information inserted in the database.
- Sub activities cost information in labor, material, equipment, and subcontract costs on daily basis, in addition the labor composition, total hours spent on the activities, daily unit costs, material consumption on each sub activity amount and executed amount.

Formats for collecting the raw data has already been presented in methodology section.

Output parameters

Based on the input parameters stated above of the cost information's of activities different reports are presented such as earned value, budget report, cost summary and performance report for each activity in the WBS.

4.2.3 Composition of the web-based Activity Based Cost Control System

Based on the excel prototype as a foundation for the web-based application, this research has enabled to designed to overcome the limitation and fulfill the objectives of the study. The activity-based cost control system has composed of raw data input, Data processing, actual cost reporting. For the study, data was collected from three projects located in Addis Ababa and being constructed by different contractors. For the purpose of the study one project is selected from each of them due to time and financial constraints.

Project Interface

The project interface is the connection point for each subsystem of the project. It's part of the Frontend or User Interface (UI) of the system. It integrates different pages including the home page and the Project page. Each page has its own functions and can be left open or closed at any time.

The first page is the home page is where the user is instructed to enter login requirements. Once the user inserts the specific login requirement then he/she is allowed to enter into a project phase where he/ she can select the project of interest.

The add project window will appear in the left corner allowing the user if it is a new project to create it by describing the name and the total budget of the project. and if it is already created it will allow the user what project to choose and to insert all the necessary cost information.

The user can create, update, add, delete, or view the project. As mentioned before, the system is applied on four different projects, but a fourth project is created for practical reasons. The fourth project is a dummy project and it's used to test the different features of the project and make necessary changes.

The system can handle multiple projects simultaneously and allow multiple users to work and share cost related information.

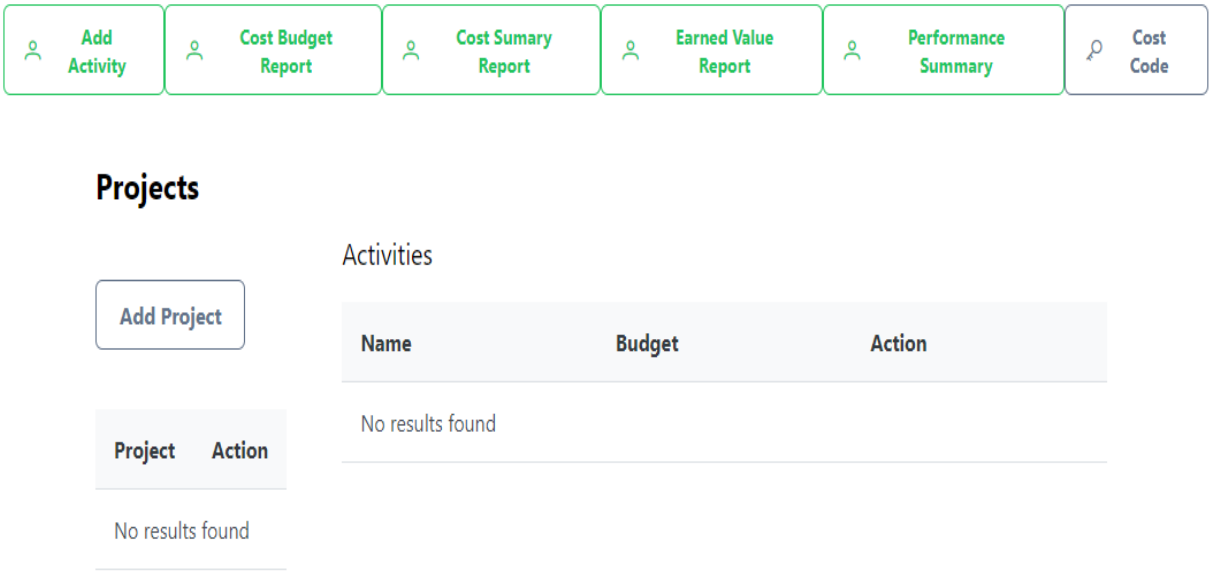


Figure 4. 1 Add/ Delete a project page.

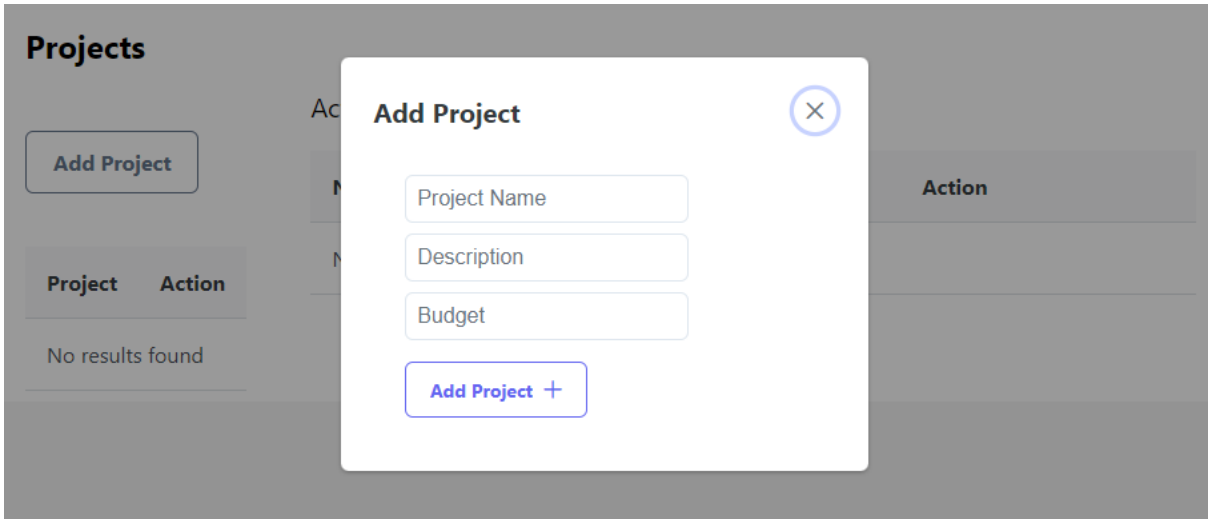


Figure 4. 2 project description and budget

The contractor can create multiple projects by providing project name as shown in the figure above. The system will register the name of the project and its total budget. Since it this is an activity-based cost control the status of the projects shall be in-progress.

4.2.3.1 The Activity Information page

The activity-based costing system uses the contractual data such that, the budgeted price and budgeted quantity from the contractor to create activity information.

There are three pages for data submission. These are activity information, sub activity information, and the sub activity daily cost information gathered from the site.

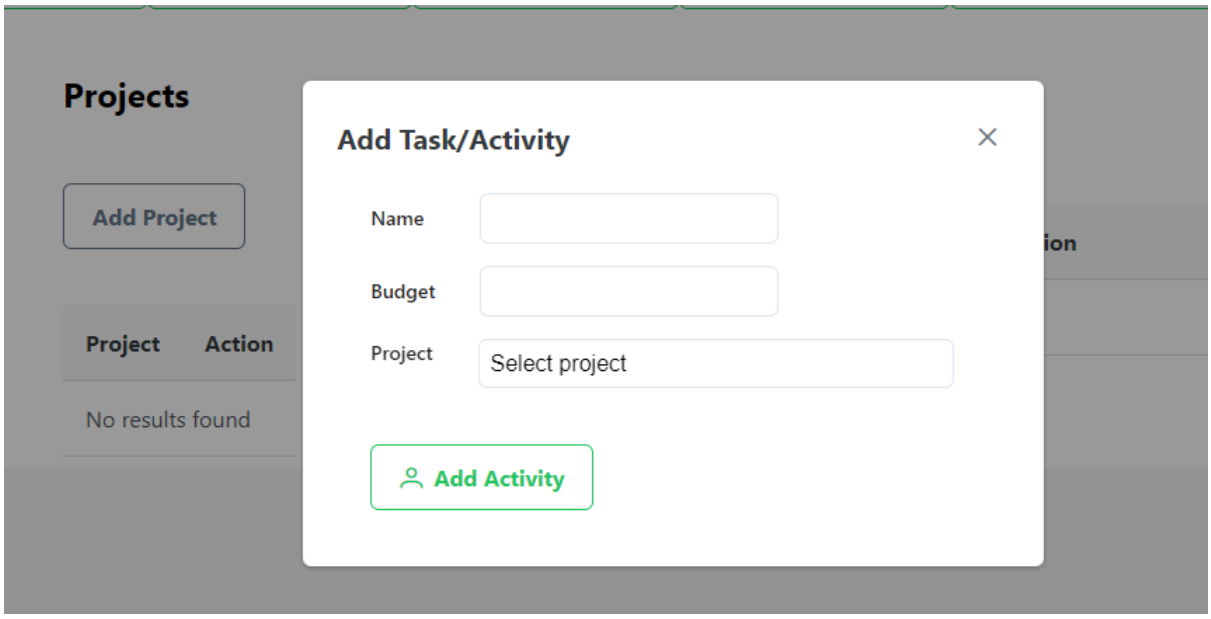


Figure 4. 3 Activity information

As it is seen from the figure above the activity information lets the user to name the activity and its planned budget from the contractual information and from which project the activity is, the activity here is the activity in the WBS or the convenient way for the contractor to control cost using the activity.

The Sub Activity Information

Once the activities are created sub activities also can be created with their respective cost codes. The system allows to create as many as sub activities as possible.

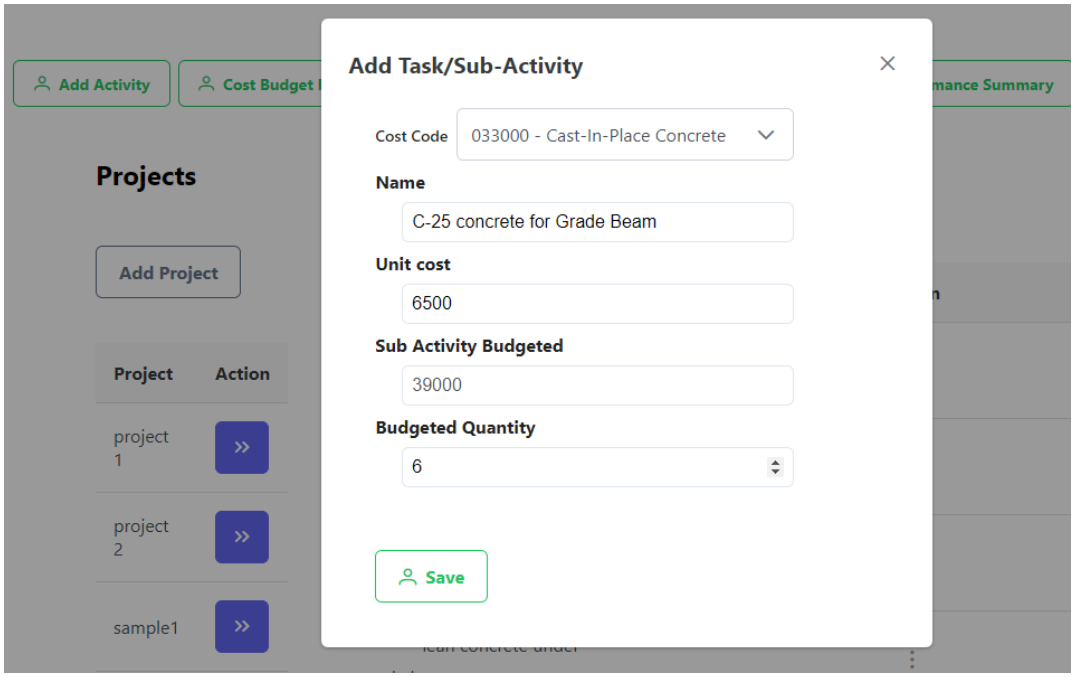


Figure 4. 4 Sub Activity Information

The Daily Cost Information

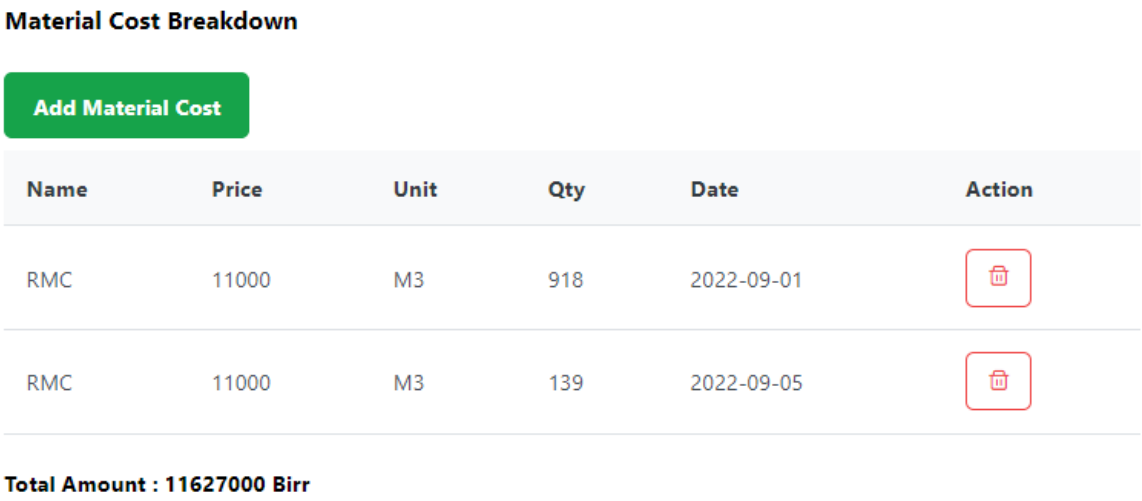
Once the sub activities are created the system allows us to enter the raw data collected from the projects, on a daily format basis. The daily cost information such as the sub activity labor cost, material cost, equipment cost and subcontract cost if it had any will be registered here, in addition the executed quantity of that activity will be also entered here.

Labor cost information includes the crew names, quantity or number, their daily cost, utilization factor and total working hour per day.

Material cost information includes the following, the description of materials used for that specific activity, the actual quantity used, the unit cost of these materials where these unit price is the price of the materials arrived on site.

The equipment cost information includes the type of machine or equipment used for the activity, the quantity, the utilization factor based on hours, the total operation hour, and the hourly rate.

Subcontract cost information includes information's based on the subcontracted activities if it is labor only or total work excluding the material the subcontract amount.



Add Labor Cost

Name	Total Hour	Cost per Hour	Qty	UF	MH	OT	Date	Action
electrician	8	43.75	2	1	4		2022-09-01	
mason	8	43.75	2	1	4		2022-09-01	
assisstant mason	8	43.75	1	1	4		2022-09-01	
carpenter	8	50	1	0.5	4		2022-09-01	
day labor	8	25	1	1	4		2022-09-01	
electrician	8	43.75	2	1	4		2022-09-05	
mason	8	43.75	3	1	4		2022-09-05	

Equipment Cost

Add Equipment Cost

Type Of Equipment	Quantity	Hourly Rate	Operation Hour	Date	Utility Factor	Action
vibrator	6	43.5	8	2022-09-01	0.75	
stationary concrete pump	1	1800	8	2022-09-01	0.75	
stationary pump	1	1800	8	2022-09-05	1	
vibrator	6	43.5	8	2022-09-05	1	

Total Amount : 28854

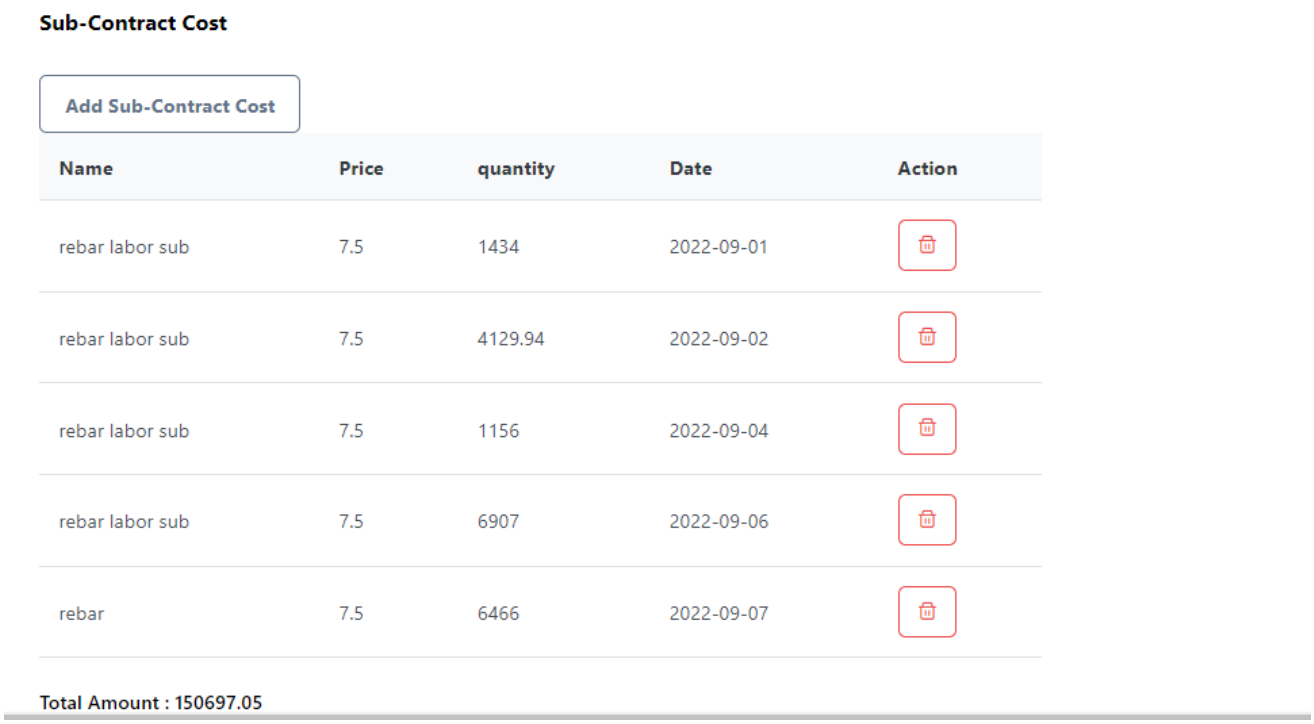


Figure 4.5 Daily cost information's (material, equipment, labor and subcontract respectively).

4.2.3.2 The Cost Report page

This window enables the reports that are needed to show the performance of the activities compared with the budgeted costs.

It compares the budgeted unit cost and the actual unit cost of activities based on daily cost information which is used as a basis for controlling costs.

Different reports are incorporated in this window based on literature reviews.

1. **Budget Report**

Budget report enables the contractor to clearly see the actual direct costs for each activity with its sub activity, since different activities will have the same cost code by selecting one cost code the system automatically generates and reports the executed quantity of different activities with the same cost code, the actual labor, material, equipment, and subcontract costs to date of the reporting period. In addition, it calculates and shows the actual unit cost of the sub activity.

2. **Earned Value Report**

This report shows the activity and sub activity total direct cost, total cost adding the percentage of indirect cost set by the contractor, the planned and the actual unit prices, the earned value, the planned value and the actual cost of each activity and the cost variances of each activity, such that it allows to know if the activity is in cost overrun or under run easily.

3. **Cost Summary**

This report shows the activity and sub activity total direct cost, total cost, the actual unit cost, the quantity and cost to complete in percentage, the forecast cost to complete that sub activity, and the cost variances of each sub activity by comparing the forecast cost to complete and the budgeted cost, such that allows to know how much will be the cost of the activity to complete

if it is not already completed. This report is very important to the contractor because it helps to show the forecast cost to complete that activity. If one must make the changes and it a great way to start from here.

4. Performance Summary Report

This report shows the activity and sub activity total direct cost, total cost, the actual unit cost, the quantity and cost to complete in percentage, the forecast cost to complete that sub activity, and the cost variances of each sub activity by comparing the forecast cost to complete and the budgeted cost, such that allows to know the cost of the activity to complete.

4.3 Case Presentation

As described in the Methodology section, non-random purposive sampling is used to make case selection of project cases in order to collect data for actual cost of activities. By outlining selection criteria.

The purpose of the cases is first to test if the developed Web Based Activity Based Cost Control application works properly and provides the necessary outputs that can be used for cost control in addition within case analysis is done to help in identifying areas where costs can be reduced or managed more effectively. Table 4.2 below describes the scope of the selected projects.

Table 4. 2 Scope of the Selected Projects

No	Description	Case One	Case Two	Case Three
		Project A	Project B	Project C
1	Project description	2B+G+9 building project	4B+G+21	Renovation building project
2	Method of Tendering	Direct Award	Direct Award	Direct Award
3	Condition of contract	PPA2011	PPA2011	PPA2011
4	Contract Type	Unit Price (admeasurement)	Unit Price (admeasurement)	Unit Price (admeasurement)
5	Contract Price including VAT	2,727,110,612.44 birr	1,649,471,613.86 birr	19,250,351.32 birr
6	Project Location	Addis Ababa	Addis Ababa	Addis Ababa
7	Project status	Active	Active	Active
8	Contractor	Private	Government	Public
9	Contractor Grade	Grade one	Grade One	Grade one
10	Client	Government	Government	Government

In addition to the information tabulated in the table 4.2, the Contractors had provided data on the WBS activities, planned quantities of activities, unit prices of activities and total budget of sub activities.

The developed web-based activity-based cost control application has used the data collected from selected case building projects owned by different contractors in Addis Ababa. Real time data is collected from each of these projects.

4.3.2 Contractors Cost Control Practice (Within Case Analysis)

Case One Contractor project A

A) The Construction Methodology

During the data collection period for project A, the status of the project was in some axes on 1st basement, 2nd basement and ground floor and the works on site were categorized in to three basic activities, that are concreting, formwork and reinforcement works. Details of the work methodology followed by the contractor is described below.

Concreting Works

- Concrete casting/Pouring is carried out with the help of truck-mounted concrete pumps and stationary concrete pumps. The truck-mounted concrete pumps are used mainly for the erection of the underground part of the building and on the ground floor.
- Electrical and diesel vibrators are used in the required amount to compact the concrete until cement paste is seen without segregation and Care was taken in the vibration process to counteract over vibration and spreading of concrete. While casting the concrete extra care was given to not displacing any reinforcement.
- The delivery of mix was directly unloaded in the concrete pumps. Care was taken to make sure that concrete mix is not dropping from more than a height of 2 meters. Concrete was placed before setting has commenced and Samples of the concrete are taken for slump and compressive test.
- After being placed in position, the concrete will be left undisturbed by any movements or thrusts while setting.
- Concrete is protected from premature drying and excessively hot temperatures from the date of casting. The concrete surface is also kept continuously wet by application of constant temperature. The watering of concrete will continue until the concrete has achieved its designed strength.
- Where the surface of concrete is covered with formwork, the surface of the form will be wetted until removed.

Reinforcement Works

- Due to space limitation of construction site, reinforcement bar is stored out of construction site in production site located at Mexico area space is given by the client.
- Preparation of rebar such as cutting and bending is performed at this site where reinforcement bar is also stored. All rebar work such as cutting, bending & place in position are executed by sub-contractor.

- Prepared Reinforcement bars are transported and delivered to construction site in sufficient quantities prior to start of concrete work, to ensure that no constructed formwork lies idle and exposed to weather due to reinforcement not being placed in position.
- Checks of slab thickness and cover over top reinforcement are made in the finished concrete directly behind the finish machine. A thickness and cover check should be made at the same location.
- Mud and other foreign material must be removed from the steel and forms prior to placement.

Formworks

- Forming system that is used for horizontal concrete structures such as slab, beam and staircases is referenced as horizontal formwork system.
- Formwork is designed and erected to safely support loads that might be applied until such load can be supported by the concrete structure.
- Most of the Formwork materials are delivered to the site after taking over the site. Formwork is placed on open stacked in an off the ground position.
- Timber and panel formwork for reusable and are cleaned, oiled & stacked.
- Formwork materials are sawn board, plywood or metal panel the use of which will be determined in compliance with the type of surface finish required.
- Rubbish, chipping, shaving and sawdust are removed from the interior of the forms before concrete is placed.
- Formwork surfaces in contact with concrete are cleaned and thoroughly wetted and treated with approved non-staining mold oil or other composition.
- Forms are constructed to the exact sizes, shapes lines and dimensions shown and as required to obtain accurate alignment, location grade, level and plumb work in finished structures.
- Slab formwork is constructed by steel props, plywood and timber for. The method for slab forms in use is a combination of timber or steel bearers and adjustable shoring.
- Columns are constructed by steel props, and timber. Before erecting column formwork, a release agent will be applied to all internal surfaces.
- Wall formworks are constructed using plywood formwork or metal sheet formwork and steel props. The appropriate sheathing such as gang forming are selected to obtain the specified finish required.
- Scaffolding is provided as a worker’s platform around the building to work at heights.

B) The Cost Control Technique in Practice

Earned Value is used as a cost controlling technique. The data for Earned Value is collected in phases of the construction, for example when the sub structure work is completed, by collecting the activities that are already completed then actual costs are calculated from the data for calculation is taken from the daily site dairy, the procurement team and subcontract team provided.

Data collection in this project is not handled very well leading to reports that are vague and incorrect does not show the status of activities and associated cost with them.

Case Two Contractor Project B

This project is a renovation project with the main tasks on site are finishing works.

A) The Construction Methodology

During the data collection period for project B, the status of the project was on fifth and six floor, the works on site were categorized in to four main activities, that are plastering, painting, tiling, and aluminum works. Details of the work methodology followed by the contractor are described below.

Plastering works

Plastering is applied to new walls that are added since it was a renovation project, demolishing and block works were done prior to the data collection period.

- The surfaces to receive plaster are thoroughly cleaned, inspected and wetted before application.
- Concrete surfaces are rubbed with cement slurry and angles of concrete & masonry surfaces dusted with cement to give additional strength.
- All chases will be cut out, services installed, and chases made good prior to application of plaster.
- Building chemicals (bonding agent) were applied on concrete surfaces to roughen up the concrete surfaces and ensure a good bond is provided for the plaster.

The work procedure was:

- Wet the surface to receive plaster one hour before, so that while starting plastering, the surface is skin dry.
- Ceiling plaster is completed before commencement of wall plaster.
- Plastering is started from the top and worked downwards to the floor.
- Throw the mortar for an area coverable by the straight edge, both vertically and horizontally in one stretch.
- Level the surface using the straight edge.
- This operation is repeated for the entire area in stages.

The final fine coat gypsum plaster to be applied by trowel and consists of one part of gypsum to three parts of lime putty, applied to a thickness of 3mm. The plaster will be finished truly level and smooth.

Ceramic Wall Finish

- Cement, lime, aggregate, tiles, admixtures, and other finishing materials, labor and tools for the satisfactory completion of the works and polishing at the end of the work is provided.
- Prior to the construction of the tiles and within a reasonable time a sample of the ceramic tiles and the necessary adhesive was submitted for approval.
- Ceramic tiles will be glazed tiles of approved color, texture, and sizes. Ceramic tiles are of required thickness for the walls. The edges of ceramic tiles for the wall are cushioned.

Painting works

- Painting material, necessary labor and tools for the preparation, priming and painting of surfaces and cleaning up at work completion were provided.
- Painters are skilled workmen who are thoroughly trained and experienced in the necessary crafts. In addition, at least one person who is thoroughly familiar with the specified requirements and capable of guiding the trade's men in the selection of materials and execution of the works was assigned.
- Paint materials are stored in enclosed spaces, secured from fire risks on site. They were stored on shelves, or ramps clearly off the ground.
- Paint materials remained sealed until used. Opened containers were closed tight to ensure sealed conditions if paint has been partially used.

The materials for painting are listed below.

- **Glue**

Glue for sizing for surfaces to receive paint will comply with the requirements and as recommended by the paints manufacturer depending on the surface to be sized.

- **Priming paints**

Oil based priming paints will be applied to surfaces under ready mixed oil base paints or conventional hard gloss paints.

Primers will be such that, they do not lose their property for a period of not less than six months in their original sealed conditions.

- **Oil paints**

Oil paints were used linseed oil-based and obtained from approved manufacturer.

Tiling

- Porcelain tiles were used in accordance with the qualities, color, textures and types indicated on drawings. Porcelain tiles were supplied from manufacturers and approved by the Engineer. Porcelain tiles are straight edged, smooth surface, and supplied in the specified thickness.
- Tiles are thoroughly soaked in water for a minimum of 15 minutes before laying and taken out just before use. Cement slurry bond coat is scrubbed to prepare slab prior to placing mortar bed.
- The mortar bed composed of 1-part cement to three parts of aggregate will be immediately applied after application of slurry bond coat and spread evenly.
- Tiles will be accurately cut and fitted to doors, wall ends, opening & projections.
- Tile joints will be grouted with the setting coat mortar.
- The finished floor is perfectly true and level.
- Tiles will be left undisturbed for 24 hours. The tiles will be topped with cement fine aggregate mortar mix 1:3 to a minimum thickness of 5mm distributed uniformly.
- The flooring will be wet for seven days.

Aluminum works

The whole aluminum work for this project is subcontracted.

- Samples of each type of work in its component material, fabricated, assembled, fixed and finished form are already produced as required for approval.
- Aluminum is either performed or formed accurate to required profiles and sizes on site.
- The specific approval of the Engineer is required for the assembly of metal work at site.
- Sliding glass doors and windows are fabricated from extruded aluminum profiles and stainless-steel tracks. Fixed and sliding interlocks are worked to be watertight and weather-stripped.

- Louver windows are produced in from 6mm thick aluminum profiles and finish aluminum including handles from inside and head and cill weather strip.
- Guard rails are produced from extruded aluminum profiles. Guard rail profiles are securely fastened to each other by bolting and screws.

Case Three Contractor Project C

A) The Construction Methodology

During the data collection period for project C, the status of the project was in some axes on Ground floor and Mezzanine floors, the works on site were categorized in to three basic activities, that are concreting, formwork and reinforcement works. Details of the work methodology followed by the contractor are described below.

Concreting Works

- Concrete casting/Pouring is carried out with the help of truck-mounted concrete pumps and stationary concrete pumps. The truck-mounted concrete pumps are used mainly for the erection of the underground part of the building and on the ground floor.
- Electrical and diesel vibrators are used in the required amount to compact the concrete until cement paste is seen without segregation and Care was taken in the vibration process to counteract over vibration and spreading of concrete. While casting the concrete extra care was given to not displacing any reinforcement.
- The delivery of mix was directly unloaded in the concrete pumps. Care was taken to make sure that concrete mix is not dropping from more than a height of 2 meters. Concrete was placed before setting has commenced and Samples of the concrete are taken for slump and compressive test.
- After being placed in position, the concrete will be left undisturbed by any movements or thrusts while setting.
- Concrete is protected from premature drying and excessively hot temperatures from the date of casting. The concrete surface is also kept continuously wet by application of constant temperature. The watering of concrete will continue until the concrete has achieved its designed strength.
- Where the surface of concrete is covered with formwork, the surface of the form will be wetted until removed.

Reinforcement Works

- Due to space limitation of construction site, reinforcement bar is stored out of construction site in production site located at Kality area space is owned by the contractor.

- Preparation of rebar such as cutting and bending is performed at this site where reinforcement bar is also stored. All rebar work such as cutting, bending & place in position are executed by sub-contractor.
- Prepared Reinforcement bars are transported and delivered to construction site in sufficient quantities prior to start of concrete work, to ensure that no constructed formwork lies idle and exposed to weather due to reinforcement not being placed in position.
- Checks of slab thickness and cover over top reinforcement are made in the finished concrete directly behind the finish machine. A thickness and cover check should be made at the same location.
- Mud and other foreign material must be removed from the steel and forms prior to placement.

Formworks

- Forming system that is used for horizontal concrete structures such as slab, beam and staircases is referenced as horizontal formwork system.
- Formwork is designed and erected to safely support loads that might be applied until such load can be supported by the concrete structure.
- Most of the Formwork materials are delivered to the site after taking over the site. Formwork is placed on open stacked in an off the ground position.
- Timber and panel formwork for reusable and are cleaned, oiled & stacked.
- Formwork materials are sawn board, plywood or metal panel the use of which will be determined in compliance with the type of surface finish required.
- Rubbish, chipping, shaving and sawdust are removed from the interior of the forms before concrete is placed.
- Formwork surfaces in contact with concrete are cleaned and thoroughly wetted and treated with approved non-staining mold oil or other composition.
- Forms are constructed to the exact sizes, shapes lines and dimensions shown and as required to obtain accurate alignment, location grade, level and plumb work in finished structures.
- Slab formwork is constructed by steel props, plywood and timber for. The method for slab forms in use is a combination of timber or steel bearers and adjustable shoring.
- Columns are constructed by steel props, and timber. Before erecting column formwork, a release agent will be applied to all internal surfaces.
- Wall formworks are constructed using plywood formwork or metal sheet formwork and steel props. The appropriate sheathing such as gang forming are selected to obtain the specified finish required.

- Scaffolding is provided as a worker's platform around the building to work at heights.

B) The Cost Control Technique in Practice

Earned Value is used as a cost controlling technique. The data for Earned Value is collected daily by collecting the actual activities on site with paper format they have prepared by themselves then encoded into an excel system prepared in-house by the contactor project team members.

Project team members are also organized into team members to ensure and collect all the necessary data on jobs on site, and resources consumed by each activity and fed in to the excel sheet they have prepared.

4.3.3 Data Collection and Reports made by the Web-Based Activity-Based Application.

4.3.1 Data Collection Process on Site

Contractor One Project A

Data was collected by formats presented in the methodology section. The data was collected for the month of September 2022 (from September 1- September 30).

The research used the project's daily cost information based of activities on WBS as a source of data for the web-based application.

In order to minimize errors created by the observer (data collector), it was needed to train the personnel's that are participating during the collection process. The research used one trial week to minimize errors created by the observer's bias and other problems. During the first week collecting data period, data was collected for seeking training and this data is not included in this research.

Table 4. 3 Personnel Qualification for Project A

Personnel	Years of experience	Number	Qualification
Site Engineer 1	5	1	BSc
Site Engineer 2	2	2	BSc

Case Two Contractor Project B

Data was collected by formats presented in the methodology section. The data was collected for the month of November 2022 (from November 6- December 30).

The research used the project's daily cost information based of activities on WBS as a source of data for the web-based application.

In order to minimize errors created by the observer (data collector), in this site also it was needed to train the personnel's that are participating during the collection process. The research used one trial week to minimize errors created by the observer's bias and other problems. During the first week collecting data period, data were collected for seeking training and this data is not included in this research.

Table 4. 4 Personnel Qualification for Project B

Personnel	Years of experience	Number	Qualification
Site Engineer 1	7	1	MSc
Site Engineer 2	4	2	BSc

The data for Labor

Labor type, number, working hour per day, cost of labor per day.

Data for Material

Material used description, quantity, and unit price of the material used after arrived on site for specific activity.

Data for Equipment

The type of equipment, quantity, and rental or depreciation price and the working hour

Subcontract data

Sub-contractor executed quantity if it is labor only subcontract and other necessary details otherwise to account for subcontract cost.

This project is a renovation project the activities during the collection of data are plastering, painting, tiling, joinery and aluminum works.

Case Three Contractor Project C

Data was collected by formats presented in the methodology section. The data was collected for the month of October 2022 (from October 2- October 30).

The research used the project's daily cost information based of activities on WBS as a source of data for the web-based application.

In order to minimize errors created by the observer (data collector), it was needed to train the personnel's that are participating during the collection process. The research used one trial week to minimize errors created by the observer's bias and other problems. During the first week collecting data period, data were collected for seeking training and this data is not included in this research.

Table 4. 5 Personnel Qualification for Project C

Personnel	Years of experience	Number	Qualification
Team leader	7	1	MSc
Site Engineer 1	5	1	BSc
Site Engineer 2	4	2	BSc

The data for Labor

Labor type, number, working hour per day, cost of labor per day.

Data for Material

Material used description, quantity, and unit price of the material used after arrived on site for specific activity.

Data for Equipment

The type of equipment, quantity, and rental or depreciation price and the working hour

Subcontract data

Sub-contractor executed quantity if it is labor only subcontract and other necessary details otherwise to account for subcontract cost.

4.3.2 The Reports of the Activity-Based Cost Control Application (Within Case Analysis)

4.3.2.1 Case Contractor One Project A

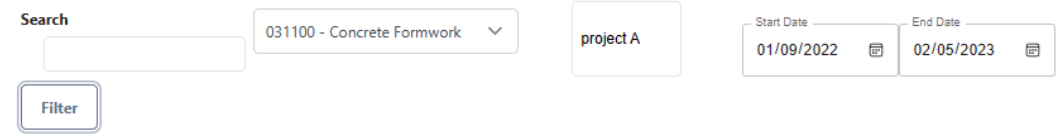
A) For Cost Code 031100 (Concrete Form work)

All the necessary information on how to calculate the actual direct cost of form work is considered and data is collected based on actual activities on site and their actual resource consumption.

The Cost Budget Report

As it is seen in figure 4.6 below, this report helps the contractor to see clearly and easily what the actual direct cost of each activity is and executed quantiles for each activity at the reporting period including the actual unit costs.

The cause for the cost overrun in each activity can be specifically referred from this cost budget report by looking and comparing if the anticipated cost for labor, materials, equipment and subcontract costs are different from the actual costs.



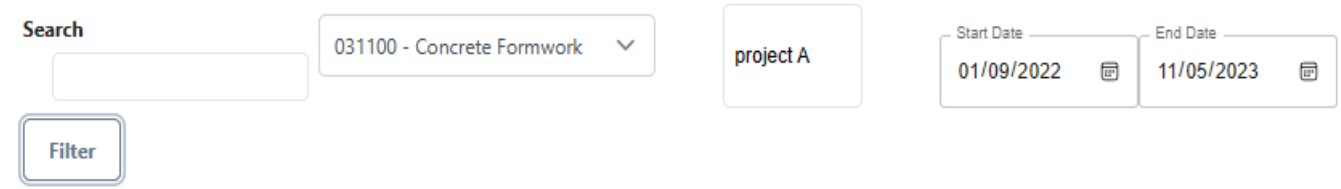
Budget Report

Activity	Sub-Activity	Budgeted Quatity ToDateBQ	Executed AmountAQ	Labor CostLC(Birr)	Material CostMC(Birr)	Equipment CostEC(Birr)	Subcontract CostSC(Birr)	Total Direct CostDC(Birr)	Total Cost To DateTC(Birr)	Actual Unit CostAUC
1st basement column	1st basement column form work	208	208.18	2000	80806	0	72863	155669	210153.15	1009.48
ground floor column	ground floor column form work	320	319.08	4200	123037	0	112210	239447	323253.45	1013.08
ground floor beam	ground floor beam form work	102	102	1200	30440	0	29580	61220	82647	810.26
ground floor shear wall	ground floor shear wall form work	420	420	4600	71978	0	147000	223578	301830.3	718.64

Figure 4. 6 Budget Report for Cost Code 031100 Project A

The Cost Summary Report

The cost summary report allows to have additional information to that of the budget report such as the % in quantity complete, the % in cost complete, the forecast cost to complete the activity and the expected cost to complete the activity by showing the variance of the budgeted cost against the forecast to complete cost .



Cost Summary Report

Activity	Sub-Activity	Executed AmountAQ	Actual CostAC(Birr)	Actual Unit CostAUC	Quantity To Complete	Cost To Complete(Birr)	Forecast To Complete	Complete Quantity(%)	Complete Cost(%)	Variance	Action
1st basement column	1st basement column form work	208.18	155669	972.09	-0.18	-174.98	155494.02	100	139	43590.02	
ground floor column	ground floor column form work	319.08	239447	975.56	0.92	897.52	240344.52	100	139	68184.52	
ground floor beam	ground floor beam form work	102	61220	780.25	0	0	61220	100	123	11648	
ground floor shear wall	ground floor shear wall form work	420	223578	692.03	0	0	223578	100	99	-2382	

Figure 4. 7 Cost Summary Report for Cost Code 031100 for Project A

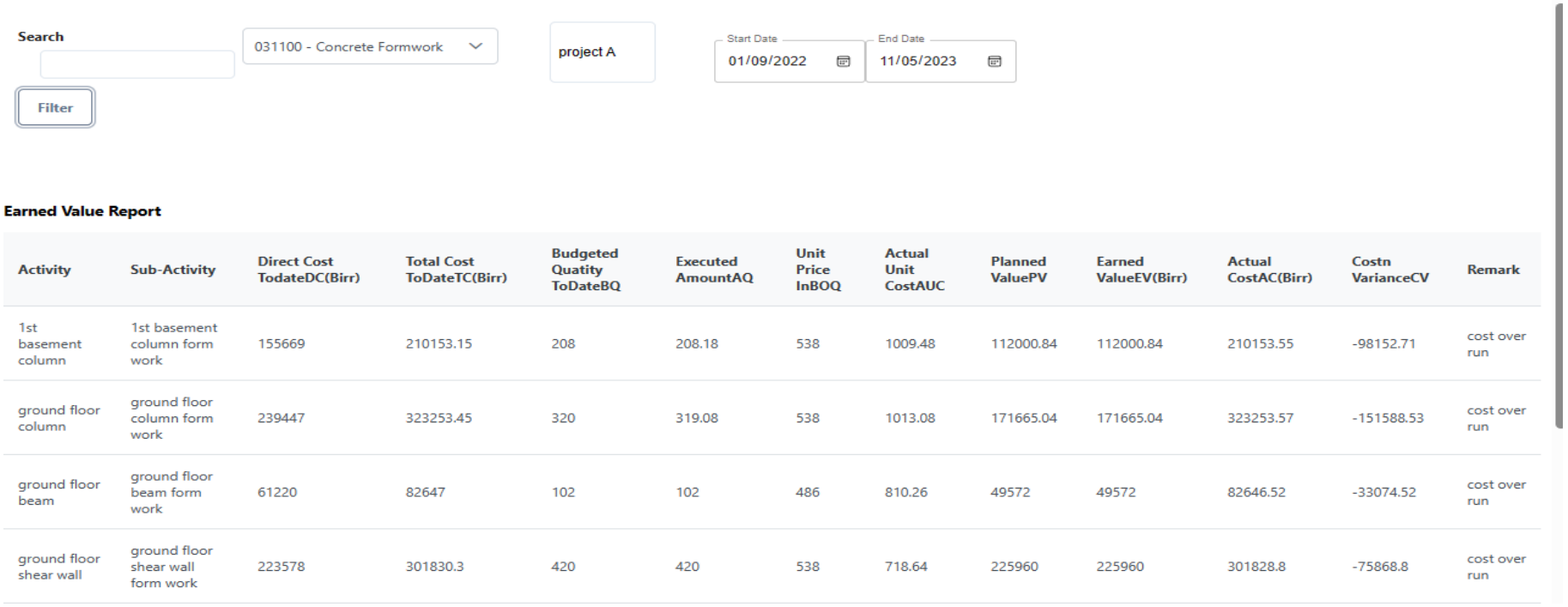
It can be clearly seen from the report that even if the quantity completed in percentage is 100% the cost complete is more than 100% for each activity, creating a variance that will be deducted from the contractor profit.

The Earned Value Report

Additional information by how much each activity is costing in a specific project can easily be seen from the earned value report and if the activity is on cost overrun or cost under run.

For example, the unit price in BOQ for 1st basement column is 538 birr/m2 however, the actual unit price is 1009.48 birr/m2. Indicating that the cost variance in birr is 98,152.71 Birr. Which further indicates this amount is expected from the contractor's own pocket.

This earned value report is a good summary of activities performance against the budget further information's on what resource the contractor is not managing well can be seen from the budget report, in this particular sub activity (formwork) for example, the budget report shows easily the anticipated material price is rather low than the actual price that is why the actual unit price for formwork is higher.



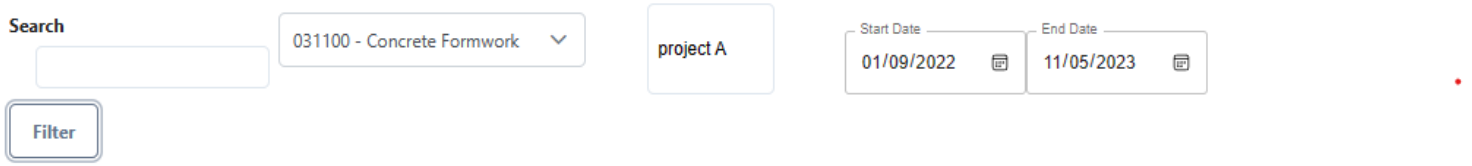
Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
1st basement column	1st basement column form work	155669	210153.15	208	208.18	538	1009.48	112000.84	112000.84	210153.55	-98152.71	cost over run
ground floor column	ground floor column form work	239447	323253.45	320	319.08	538	1013.08	171665.04	171665.04	323253.57	-151588.53	cost over run
ground floor beam	ground floor beam form work	61220	82647	102	102	486	810.26	49572	49572	82646.52	-33074.52	cost over run
ground floor shear wall	ground floor shear wall form work	223578	301830.3	420	420	538	718.64	225960	225960	301828.8	-75868.8	cost over run

Figure 4. 8 Earned Value Report for cost Code 031100 for Project A

The Performance Summary Report

This report indicates the remaining quantity to complete and the remaining cost to complete in percentage and the forecast at completion each activity on site.



Performance Summary Report

Activity	Sub-Activity	Budgeted Quatity ToDateBQ	Executed AmountAQ	Quantity To CompleteQC	Budgeted Cost ToDateBC	Actual CostAC(Birr)	Percent Complete To Date InCostACBQ	Percent Complete At Completion ToDateACBC	ForeCast CostAtGoodFC(Birr)	Variance InCost
1st basement column	1st basement column form work	208	208.18	-0.18	111904	263080.61	100	235	111949	4500
1st basement column	1st basement column form work	208	208.18	-0.18	111904	263080.61	100	235	111949	4500
ground floor column	ground floor column form work	320	319.08	0.92	172160	404665.43	100	235	172198	3800
ground floor column	ground floor column form work	320	319.08	0.92	172160	404665.43	100	235	172198	3800

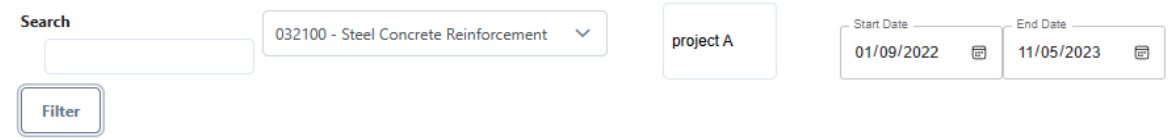
Figure 4. 9 Performance Summary Report for Cost Code 031100 for Project A

B) **For Cost Code 032100 (Concrete Reinforcement)**

The Cost Budget Report

As it is seen in figure 4.10 below, this report helps the contractor to see clearly and easily what the actual direct cost of each activity are and executed quantiles for each activity at the reporting period including the actual unit costs.

It can be easily seen on causes for the higher costs in each activity, from this cost budget report by looking and comparing if the anticipated cost for labor, materials, equipment and subcontract costs are different from the actual costs.



Budget Report

Activity	Sub-Activity	Budgeted Quatity ToDateBQ	Executed AmountAQ	Labor CostLC(Birr)	Material CostMC(Birr)	Equipment CostEC(Birr)	Subcontract CostSC(Birr)	Total Direct CostDC(Birr)	Total Cost To DateTC(Birr)	Actual Unit CostAUC
1st basement beam	1st basement beam reinforcement	17159	17159	2400	2656855	0	128557.5	2787812.5	3763546.88	219.33
1st basement column	1st basement column reinforcement	10182	10383	2400	1862355	0	84660	1949415	2631710.25	253.46
ground floor column	ground floor column reinforcement	27641	23947.94	4800	4311520	0	179602.05	4495922.05	6069494.77	253.45
ground floor beam	ground floor beam reinforcement	1900	1899	800	313170	0	14242.5	328212.5	443086.88	233.33

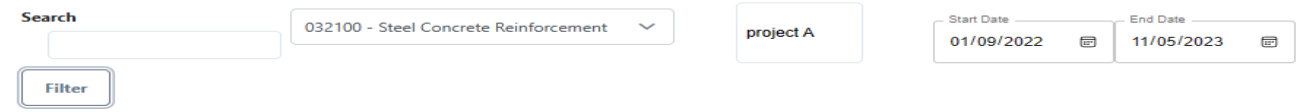
Figure 4. 10 Budget Report for Cost Code 032100 Project A

Earned Value Report

Additional information about how much each activity is costing in a specific project can easily be seen from the earned value report and if the activity is on cost overrun or cost underrun.

For example, the unit price in BOQ for 1st basement column is 97 birr/kg however, the actual unit price is 219 birr/kg. Indicating that the cost variance in birr is 1,624,524 Birr. Which further indicates this amount is a rather significant payment expected from the contractor profit from one activity.

This earned value report is a good summary of activities performance against the budget, further information's on what resource the contractor is not managing well can be seen from the budget report, in this particular sub activity (reinforcement) for example, the budget report shows easily the anticipated material price is rather low than the actual price and that is why the actual unit price for reinforcement is higher and there is also a higher escalation of the price of reinforcement in the Ethiopian market, so appropriate action should be taken by the contractor in order to address this material resource control if not, it is inevitable that the contractor operation in this particular activity will be unprofitable as well as will lead to cost and time overrun.



Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
1st basement beam	1st basement beam reinforcement	2787812.5	3763546.88	17159	17159	96	219.33	1647264	1647264	3763483.47	-2116219.47	cost over run
1st basement column	1st basement column reinforcement	1949415	2631710.25	10182	10383	97	253.46	1007151	1007151	2631675.18	-1624524.18	cost over run
ground floor column	ground floor column reinforcement	4495922.05	6069494.77	27641	23947.94	97	253.45	2322950.18	2322950.18	6069605.39	-3746655.21	cost over run
ground floor beam	ground floor beam reinforcement	328212.5	443086.88	1900	1899	97	233.33	184203	184203	443093.67	-258890.67	cost over run

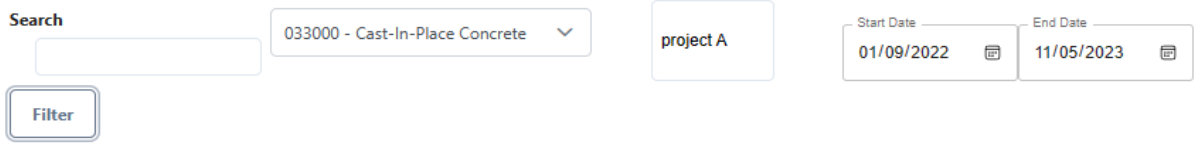
Figure 4. 11 Earned Value Report for Cost Code 032100 for Project A

C) For Cost Code 032100 (Cast in place Concrete)

The Cost Budget Report

As it is seen in figure below, this report helps the contractor to see clearly and easily what the actual direct cost of each activity are and executed quantiles for each activity at the reporting period including the actual unit costs.

It can be easily seen on causes for the higher costs in each activity, from this cost budget report by looking and comparing if the anticipated cost for labor, materials, equipment and subcontract costs are different from the actual costs.



Budget Report

Activity	Sub-Activity	Budgeted Quatity ToDateBQ	Executed AmountAQ	Labor CostLC(Birr)	Material CostMC(Birr)	Equipment CostEC(Birr)	Subcontract CostSC(Birr)	Total Direct CostDC(Birr)	Total Cost To DateTC(Birr)	Actual Unit CostAUC
2nd basement column	2nd basement column concrete	113	113	9550	1356000	16488	0	1382038	1865751.3	16511.07
1st Basement slab	1st Basement slab concrete work	181	179	2150	2058500	28854	0	2089504	2820830.4	15758.83
1st basement beam	1st basement beam concrete	65	65.01	1975	715000	8244	0	725219	979045.65	15059.92
1st basement stair case	1st basement stair case concrete	3	3	0	13911	0	0	13911	18779.85	6259.95
2nd basement shear wall	2nd basement shear wall concrete	35	34.17	0	437000	0	0	437000	589950	17265.14

The Cost Summary Report

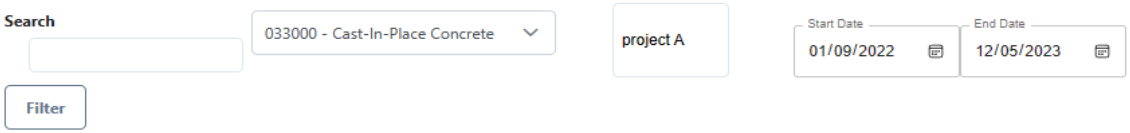
The cost summary report allows to have additional information to that of the budget report such as the % in quantity complete, the % in cost complete, the forecast cost to complete the activity and the expected cost to complete the activity by showing the variance of the budgeted cost against the forecast to complete cost.

Earned Value Report

Additional information about how much each activity is costing in a specific project can easily be seen from the earned value report and if the activity is on cost overrun or cost underrun.

For example, the unit price in BOQ for 2nd basement column is 4894 birr/m3 however, the actual unit price is 16511 birr/m3. Indicating that the cost variance in birr is 1,312,728 Birr. Which further indicates this amount is rather significant and an extra cost is expected from the contractor profit for one activity.

This earned value report is a good summary of activities performance against the budget, further information's on what resource the contractor is not managing well can be seen from the budget report, in this particular sub activity (concreting) for example, the budget report shows easily the anticipated material price is very low than the actual price and that is why the actual unit price for concreting is higher and there is also a higher escalation of the price of components for concreting work such as cement, sand and coarse aggregate in the Ethiopian market, so appropriate action should be taken by the contractor in order to address this material resource control if not, it is inevitable that the contractor operation in this particular activity will be unprofitable as well as will lead to cost and time overrun.



Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
2nd basement column	2nd basement column concrete	1382038	1865751.3	113	113	4894	16511.07	553022	553022	1865750.91	-1312728.91	cost over run
1st Basement slab	1st Basement slab concrete work	2089504	2820830.4	181	179	4637	15758.83	830023	830023	2820830.57	-1990807.57	cost over run
1st basement beam	1st basement beam concrete	725219	979045.65	65	65.01	4637	15059.92	301451.37	301451.37	979045.4	-677594.03	cost over run

Figure 4. 12 Earned Value Report for Cost Code 033000 for project A

If we see the summary of one activity on project A for example, the 1st Basement column work which is composed of the formwork, reinforcement and concreting work as shown on the table below the variance of each sub activity is significant unless correction action is applied as soon as possible it will be difficult for the contractor to continue its work.

Most of the contractors cost for a particular activity are from the material price escalation in the country however, enough stock shall also be acquired prior to start of such activities in order to avoid the material price increase.

Table 4. 6 Summary of an Activity Performance against the Budgeted Cost for Project A

Activity location	Sub Activity	Budgeted quantity	Executed Quantity	Unit price in BOQ	Actual Unit price	Budgeted Cost	Actual Cost	Variance	Quantity Complete in %	Cost Complete in %
1st basement column	Concrete formwork	208	208	538	972	111,904	202,176	-90,272	100	180.7
1st basement column	Reinforcement work	10,182	10,383	97	253.46	987,654	2,631,710	-1,644,056	102	266.5
1st basement column	Concreting work	65	65	4894	16511.07	318,110	1,073,215	-755,105	100	337.37

4.3.2.2 Case Contractor Two Project B

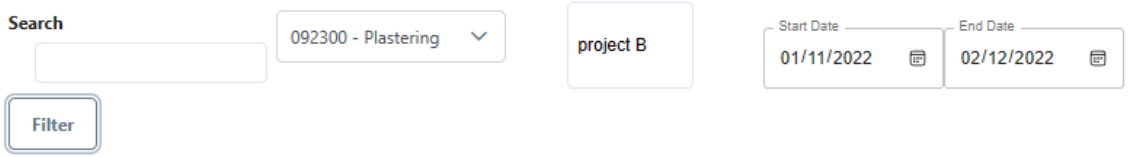
A) Water Proofing Work

This activity shows a good accomplishment in cost and in quantity the actual unit price is 586.81 birr/m2 which is less than the unit price in BOQ.

Figure 4. 13 Earned Value Report for Cost Code 071100 for Project B

B) Plastering work for Project B

The accomplishment of this activity is also good the cost of gypsum cove is a little bit higher however it is not that much considering the variance in cost is 6,102 birrs.



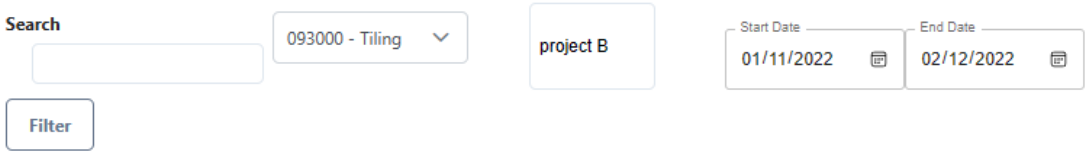
Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
Finishing Works	chesiling work	43280	58428	128	128	553	456.47	70784	70784	58428.16	12355.84	cost under run
Finishing Works	gypsum cove	30284	40883.4	130	130	267.55	314.49	34781.5	34781.5	40883.7	-6102.2	cost over run

Figure 4. 14 Plastering work (092300) for Project B

C) Tiling work for project B

Tiling work in floor tiling is in cost overrun and the earned value report shows by how much the variance is with the budgeted cost, the cause can further be discussed from other reports, that if it is because of higher material or labor cost or not.



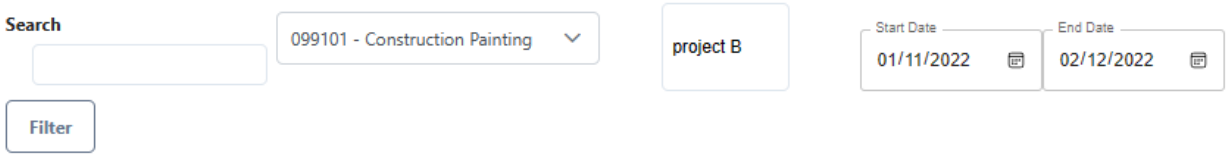
Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
Finishing Works	porcelain flooring	1054531.5	1423617.53	253	252.5	4452	5638.09	1124130	1124130	1423617.73	-299487.73	cost over run
Finishing Works	wall tile	157036	211998.6	180	180	1576.39	1177.77	283750.2	283750.2	211998.6	71751.6	cost under run
Finishing Works	skirting	183176	247287.6	166	166	642	1489.68	106572	106572	247286.88	-140714.88	cost over run

Figure 4. 15 Tiling work for Project B

D) Painting work

There is an increase in the unit price of painting work costing the contractor 56,542 birr. This was mainly due to the price increase for paint in Ethiopian market and the contractor did not acquire material before because of not having enough storage place on site.



Earned Value Report

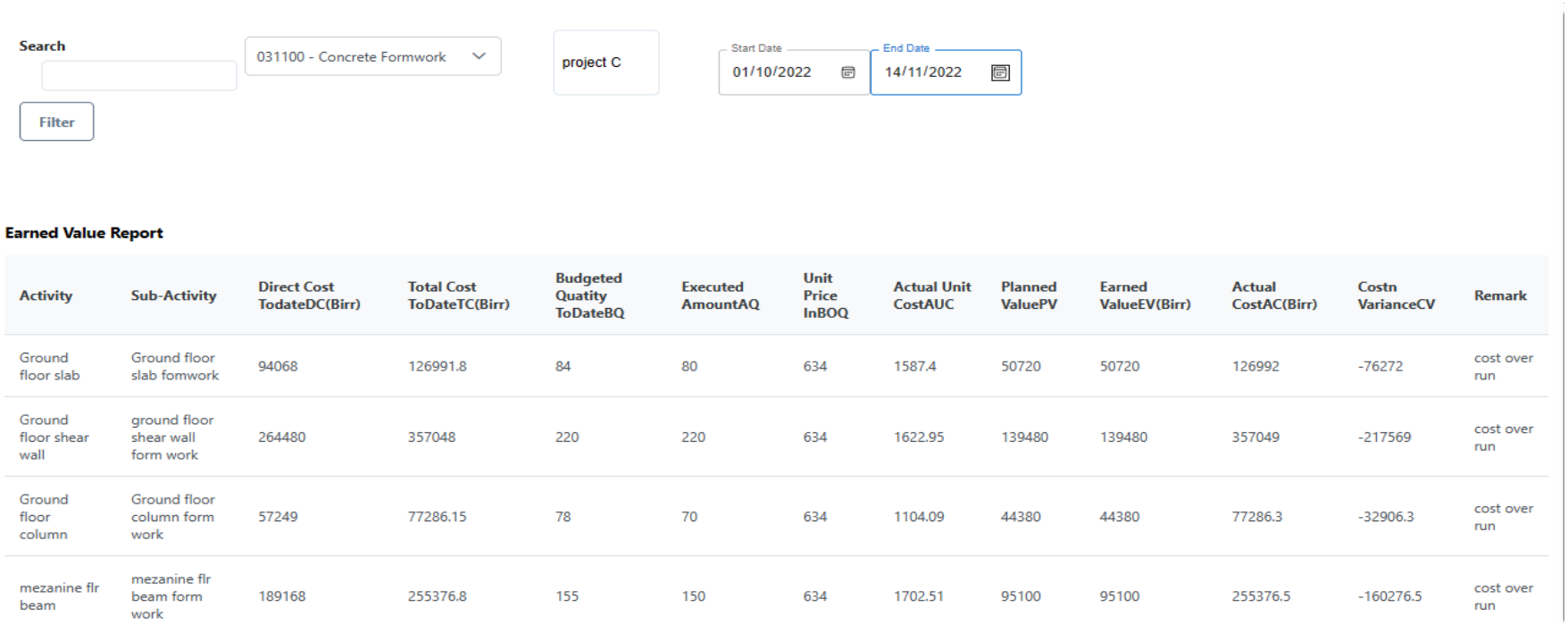
Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
painting	jutan painting	219725	296628.75	1629	1629	147.38	182.09	240082.02	240082.02	296624.61	-56542.59	cost over run
painting	quartz painting	154076.26	208002.95	338.5	338.5	2500	614.48	846250	846250	208001.48	638248.52	cost under run

Figure 4. 16 Painting Work for Project B

4.3.2.3 Case Contractor Three Project C

A) For Cost Code 031100 (Concrete Form work)

The earned value report for concrete formwork in project C is a shown below, the report indicates the actual cost, budgeted cost, the variance in cost of formwork at different levels in the project during the reporting period, all formworks are in cost over run and a significant amount of money is expected from the contractor to cover the costs, it is becoming unprofitable operation due to escalation of material cost in the Ethiopian market the management shall give a consideration on minimizing such costs for example using reusable formworks even if the initial cost is higher they can be used for a long period. Other reports such as the cost budget report, the cost summary report as well as the performance report can be referred for further information.



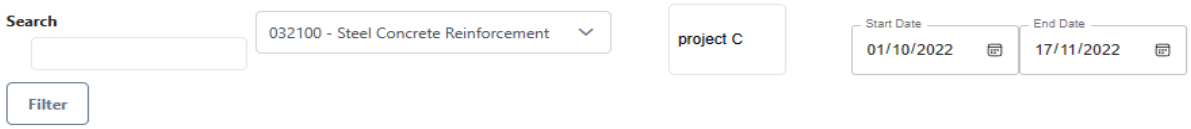
Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
Ground floor slab	Ground floor slab fomwork	94068	126991.8	84	80	634	1587.4	50720	50720	126992	-76272	cost over run
Ground floor shear wall	ground floor shear wall form work	264480	357048	220	220	634	1622.95	139480	139480	357049	-217569	cost over run
Ground floor column	Ground floor column form work	57249	77286.15	78	70	634	1104.09	44380	44380	77286.3	-32906.3	cost over run
mezanine flr beam	mezanine flr beam form work	189168	255376.8	155	150	634	1702.51	95100	95100	255376.5	-160276.5	cost over run

Figure 4. 17 Earned Value Report for Formwork in Project C

B) Reinforcement work in Project C

The earned value report for reinforcement work for project C is a shown below in figure 4.18 indicating it is a good accomplishment by the contractor, the cost is in under run this is mainly because of acquiring the reinforcement bars early on the start of the project.



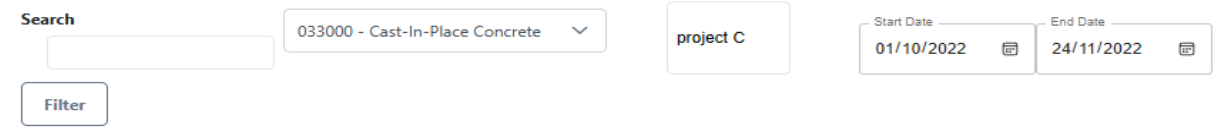
Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
Ground floor column	Ground floor column Reinforcement	109311.88	147571.04	2500	2500	80	59.03	200000	200000	147575	52425	cost under run
mezanine flr beam	mezanine flr beam reinforcement	77633.91	104805.78	1500	1500	80	69.87	120000	120000	104805	15195	cost under run
Mezanine floor slab	Mezanine floor slab reinforcement	1211737.42	1635845.52	25000	24800	80	65.96	1984000	1984000	1635808	348192	cost under run

Figure 4. 18 Earned Value Report for Concrete Reinforcement for Project C

C) Concrete Work

From the earned value report shown below it can be seen that at different levels of the project site the actual cost of concrete work is higher and the activity is on cost overrun. There is a significant increase in cost of concreting work than the budgeted cost and this particular operation is unprofitable due to material cost escalation and unavailability particularly in cement in the market. The Ready-Mix Concrete suppliers also has to add higher prices due to this unpredictable market continuously



Earned Value Report

Activity	Sub-Activity	Direct Cost TodateDC(Birr)	Total Cost ToDateTC(Birr)	Budgeted Quatity ToDateBQ	Executed AmountAQ	Unit Price InBOQ	Actual Unit CostAUC	Planned ValuePV	Earned ValueEV(Birr)	Actual CostAC(Birr)	Costn VarianceCV	Remark
Ground floor column	Ground floor column concreting	959127	1294821.45	86	84	4354	15414.54	365736	365736	1294821.36	-929085.36	cost over run
Ground floor slab	Ground floor slab concreting	1841580	2486133	165	165	4354	15067.47	718410	718410	2486132.55	-1767722.55	cost over run
Ground floor shear wall	Ground floor shear wall concreting	1791052	2417920.2	165	160	4354	15112	696640	696640	2417920	-1721280	cost over run

Figure 4. 19 Concrete Work in Project C

4.4 Validation and Verification of the Web-Based Activity Based Application

Overall, software validation is a critical step to ensure that the software performs its intended use and meets the specified requirements.

A software validation is the process of evaluating a software system or application to determine whether it meets the specified requirements and performs its intended functions correctly.

The steps involved in software validation may vary based on the software development process, but generally, the following steps are followed:

1. **Requirement Analysis**

   In this stage, the software requirements are analyzed and documented accurately. The requirements must be measurable, traceable, and complete.

   Software requirement is a functional or non-functional need to be implemented in the system. Functional means providing service to the user.

   For example, in this Web-Based Activity Based Cost Control system for when the user touches the project toggle, it enables the user to create and view projects activity and cost details.

   Whereas in software non-functional requirement, it can be a performance requirement. For example, a non-functional requirement is where every page of the system should be visible to the users within 5 seconds.

2. **Planning**

   In this stage, the planning of validation activities is done. It includes setting objectives, developing test strategies, and outlining timelines for the validation process.

3. **Design Review**

   In this stage, the software design is reviewed for quality, accuracy, and completeness. The design review ensures that the software is designed to meet the specified requirements.

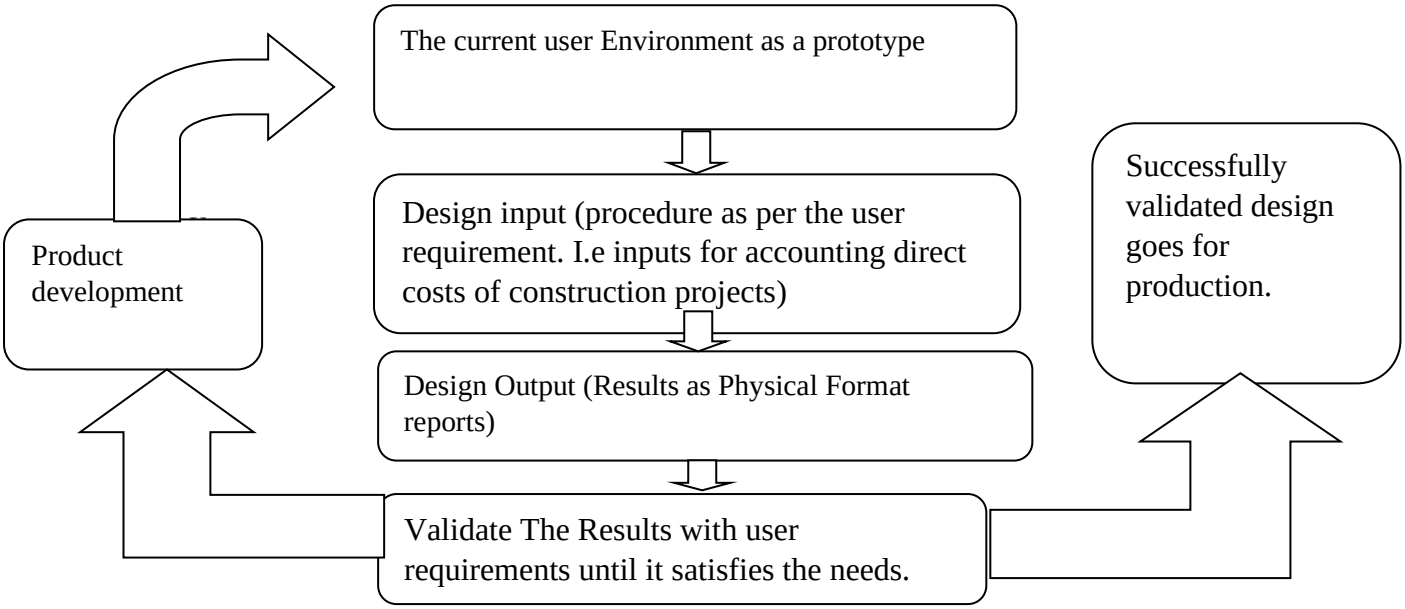


Figure 4. 20 Validation Process

In this research the software design validation is done by referring different literatures on how to account for direct cost of activities in construction projects and the user's current practices of accounting these costs.

After the Web Based Application for Activity-Based Cost Control is developed user requirements of inputs and outputs are tested.

4. **Test Protocol Development:**

In this stage, test protocols are developed based on the software requirements. The test protocol outlines the test methods, acceptance criteria, and the expected results.

Software testing is the process of evaluating and verifying that a software product or application does what it is supposed to do. The benefits of testing include preventing bugs, reducing development costs and improving performance.

Once the tests are executed, the results are analysed to determine whether the software meets the required standards. The validation is done at the on-project sites office by the author with the collaboration of the contractor's project teams of the respective projects.

First, the web-based application has been thoroughly checked. The web-based application is tested on commonly used web browsers like Edge, Chrome, Opera, and Firefox. It was found to be working smoothly on all browsers.

Then users are created to check the project interface integration. The validation for the data input and processing subsystem consisted of three distinct steps.

The validation process aims at making sure the system inputs and outputs are accurate and reliable. The direct cost of activities and sub activities are checked with the system and compared with the sum prepared in excel. When there is a difference manual checking is used to identify the changes.

Since the system can calculate each sub activities cost information entered by the user it easy to find the errors, and all the information is able to be seen in the page for each sub activity. The contractor project manager verifies the accuracy of the system output by cross checking with manual calculation. The processing speed and accuracy of the system were also checked.

There was no error found in the calculation done by the system and the cost processing time was less than one minute for each sub activity.

5. Documentation and Reporting

In this stage, the validation process is documented, and a final report is prepared. The report includes the cost information's provided it is able to put necessary output by calculating actual cost performance of activities.

The application was able to prepare all the summary reports and follow-up reports for each project which the author got positive feedback from project team members of contractors under study. In addition, the user interaction easiness, reporting and filtering based on cost codes were duly acknowledged by the team members of the study, other necessary and additional information's from the web-based applications provided to project teams.

4.5 Security

The system can handle multiple users and runs on web pages therefore, security is a major concern. The use of PHP helps in building a secure web-based application. The database is secured using several techniques. These techniques include using different servers for the database and web pages, hash encryption, and regularly backing up the database.

CHAPTER 5 CONCLUSION AND RECOMMENDATION

The main objective of the research was to develop a web-based activity-based cost control system for contractors particularly in building projects. The specific objectives were to create an automated activity-based cost control system for having cost recorded data for activities mainly the direct cost of the activities and sub activities ultimately for enhancing the cost performance of projects, and for follow-up, with a secure database that has integrated project interface, and a reporting system.

The study was aimed at reducing time, error, and paperwork while achieving cost control. In addition to have a cost record of data for future estimation and aimed in assisting cost related decisions, by developing an integrated activity-based cost control system the web-based application has achieved its main and specific objectives as presented below.

5.1 Conclusion

- The study has developed a web-based application that integrates actual cost information of activities and sub activities with their cost codes and enables, where and how the deviation of quantity and cost has occurred from the budgeted quantity and cost.
- Since a data base is provided for the projects, it enables show the crew composition for sub activities, the actual material usage of activities and executed quantities, and equipment usage.
- The information gathered for cost indirectly helps to have information's when activities and sub activities are started and ended so it can also help to prepare as built schedules.
- The web-based application was able to record the actual cost information of the activities and sub activities which could reduce the error, time, and paperwork and will help for future reference to other bids.
- Furthermore, the system shows cost performance of activities, that enables the contractor on how he/she can make informed decision based on them and helps to make changes early if needed.

5.2 Recommendation

The implementation of this web-based application could provide a platform for not only cost control based on activities but also to have cost information of building projects and indirectly to prepare as built schedules. The author recommends the use of documentation and reports collected through the implementation of this system on building projects as a foundation to enhance future studies to pinpoint and quantify the causes of cost overruns, unrealistic estimations and provide practical solutions.

Since the web-based application developed doesn't address all cost aspects of a project only those after the construction has started and the direct cost; future studies that incorporate those should be performed. The author encourages similar studies that aim to automate the different aspects of project management and cost management by integrating with web-based applications, to provide practical solutions to the construction industry.

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APPENDIXES

APPENDIX A: DATA COLLECTION FORM

Introduction

The research titled Web-Based Application for Activity Based Cost Control: For Contractors on selected building projects, it will be conducted for the partial fulfillment of the requirements of the Master of Science Degree in Construction Technology and Management. This data collection form is prepared by the author. The information gathered from the document analysis using this form will be kept strictly confidential and will be used for academic purposes only. All the data you provide will be used for the generalized analysis of the research and no organization or individual will be identified and mentioned in the process.

I am grateful for your cooperation and assistance!

Date	Activity Location	Activity Name	Unit	Executed Quantity	Actual Labor cost										Actual Material cost					Actual Equipment Cost					
					Crew members	daily cost	Quantity Man Power	U/F	Morning	Afternoon	OT	Working Hr.	Indexed Actual labor cost Per Hr.	Labor Unit cost	Description	Unit	Actual Qty. required (Qty*)	Unit price	Actual Material Cost	Type of Machine	Quty. Equipment	UF	Operation Hr.	Hourly Rate	Equipment unit Cost

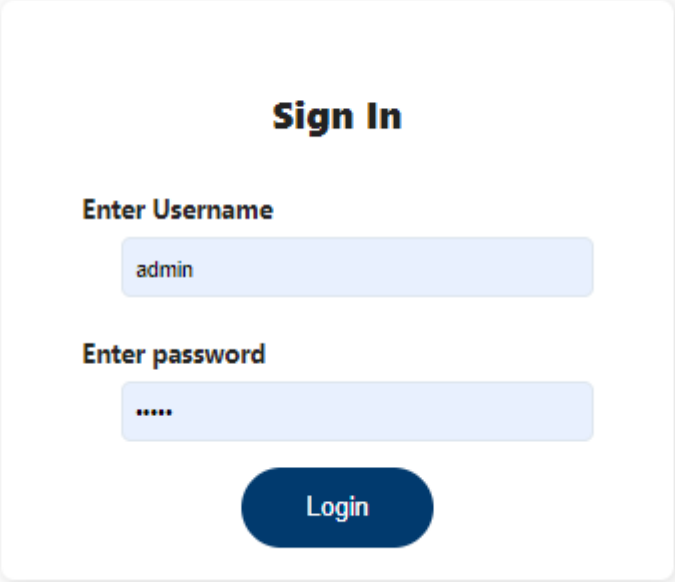
APPENDIX B: USER MANUAL

Introduction

This manual is prepared as part of the thesis research titled Web-Based Application for Activity-Based Construction Cost Control in Selected Building Projects in Addis Ababa. This web-based application provides an automated, cost information data base and control. It provides reports and status based on the actual cost of activities on site. This is a web-based application works on Google Chrome, Mozilla, or other common browsers and has been tested and found functional on the Windows operating system.

How to Login to Activity Based Cost Control system

The user creates a username and password that will be saved by the system. The user will then use this username and password to log in. The user will input the user and password and press the login button. Some web pages save the username and password if required. To make it more secure the password should contain uppercase and lowercase letters. Additionally, it should contain numbers and special characters with a minimum total length of 8 characters.

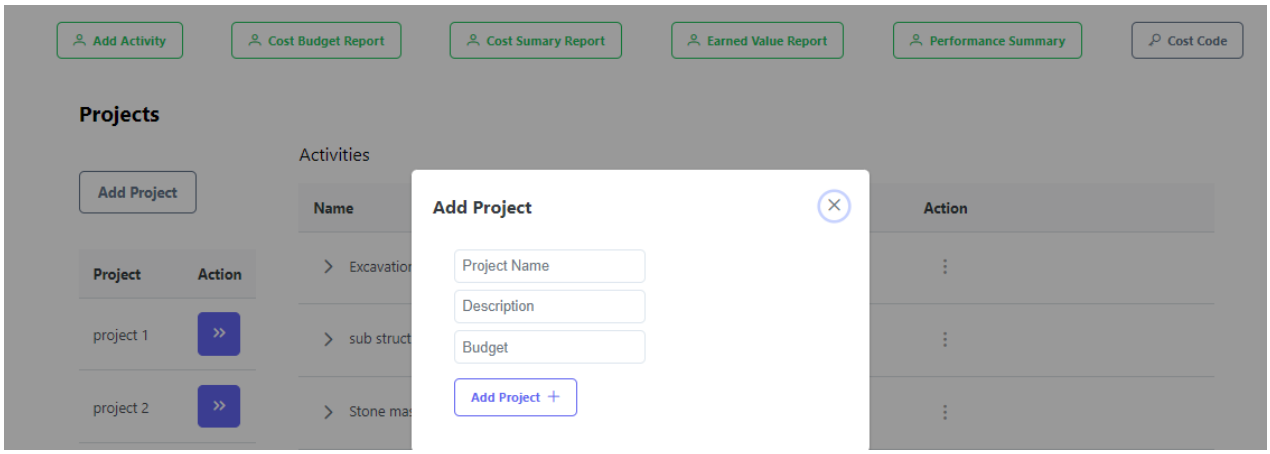


Main Window

Once you're logged into the system, it will display the main window page. The left side of the window shows the project lists, and the top part shows the add activity and report section.

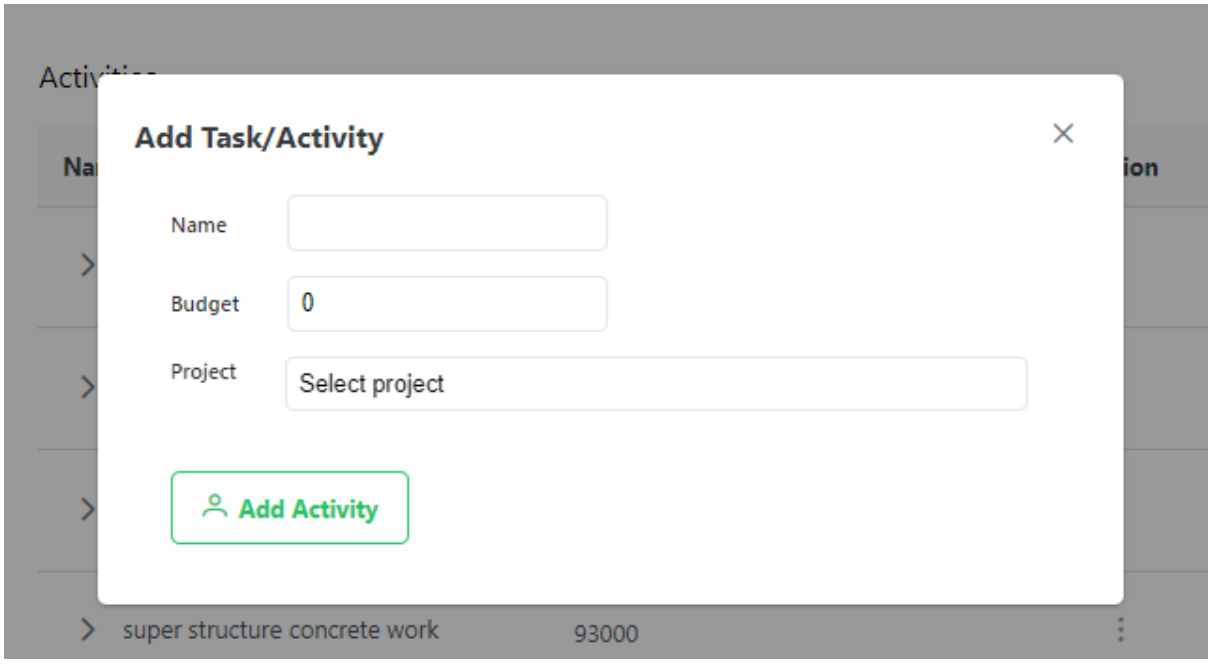
Step 1: Add Project

By Click on 'Projects' it opens the projects window on the middle. Here the contractor creates the project with its total project cost and description name for the project.



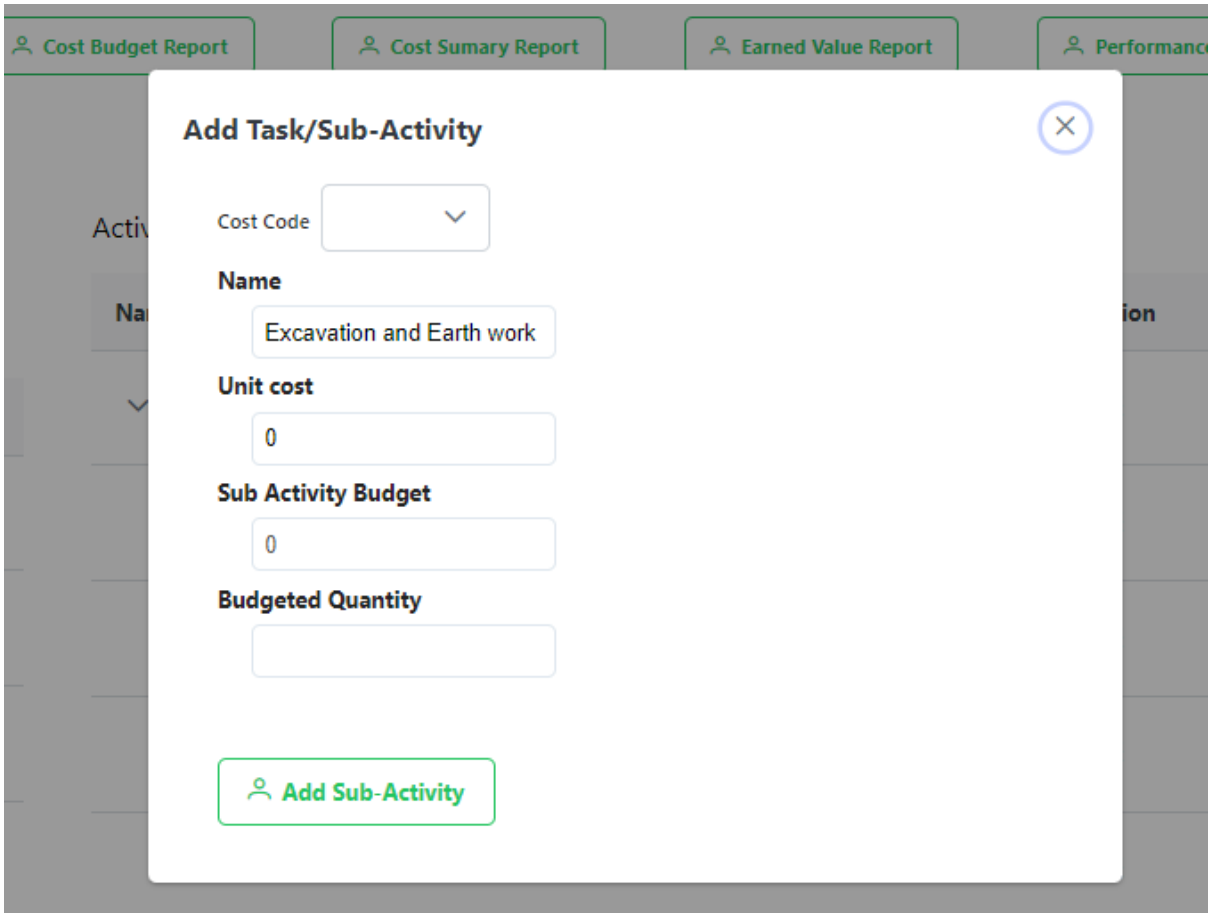
Step 2: Add Activity

Once the project is created click on add activity, the add activity button is on the top left of the home window. The contractor can add activities based on WBS list or in a convenient way to see the status of the activity in a project. In addition, this add activity button allows to select in which project the activity is in.



Step 3: Add Sub Activity

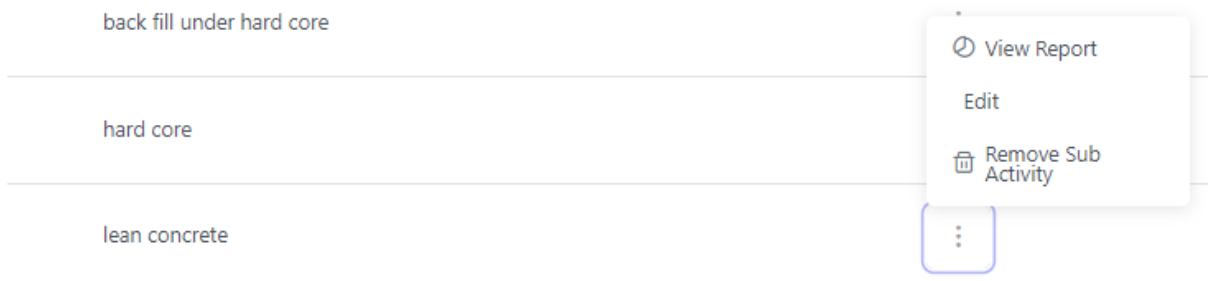
After the activity is created by right clicking on the activity one can add or create the list of sub activities in that particular activity in the project.

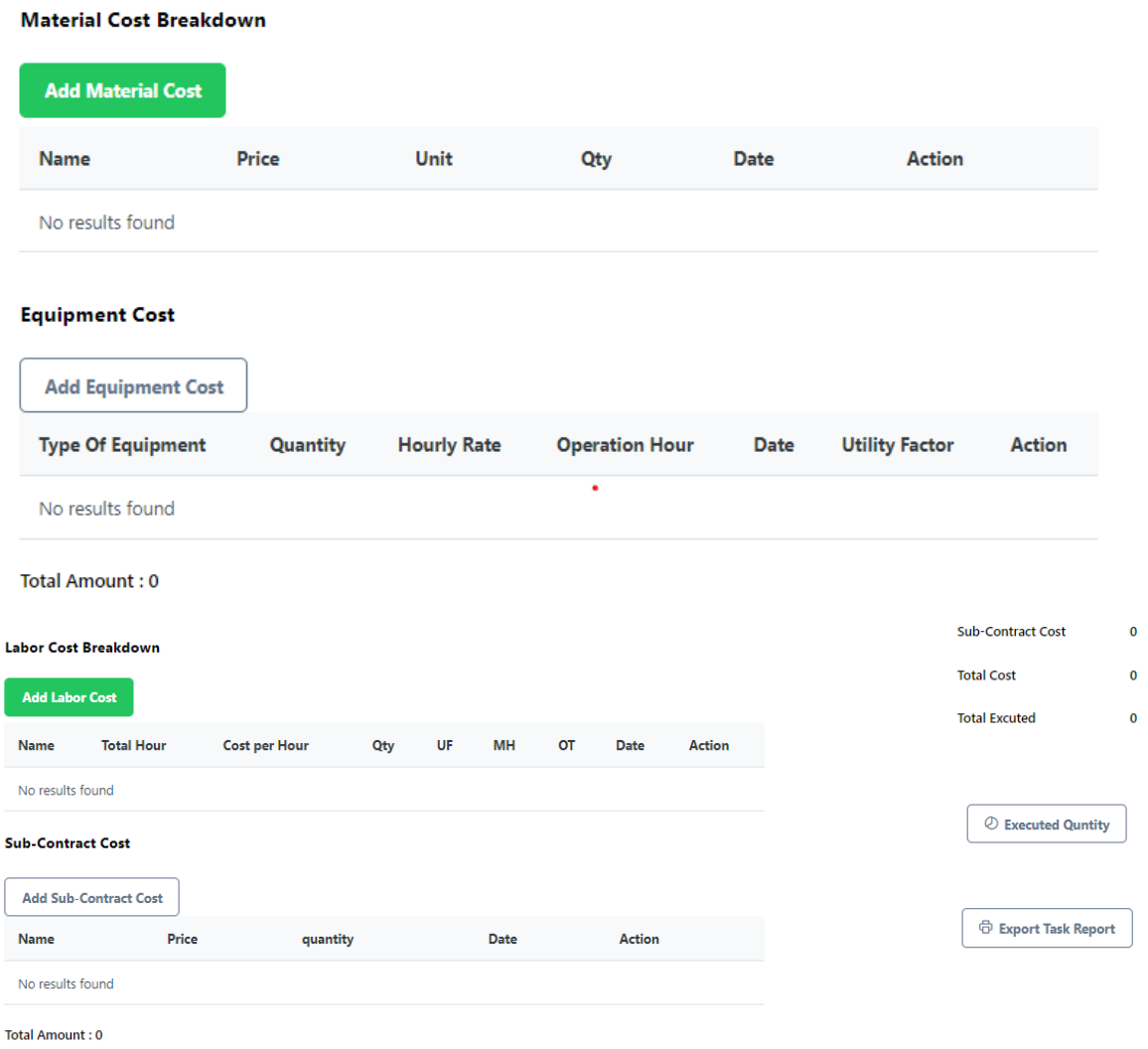


The user here selects a cost code for particular sub activity then put the unit price and the budgeted quantity provided in the BOQ.

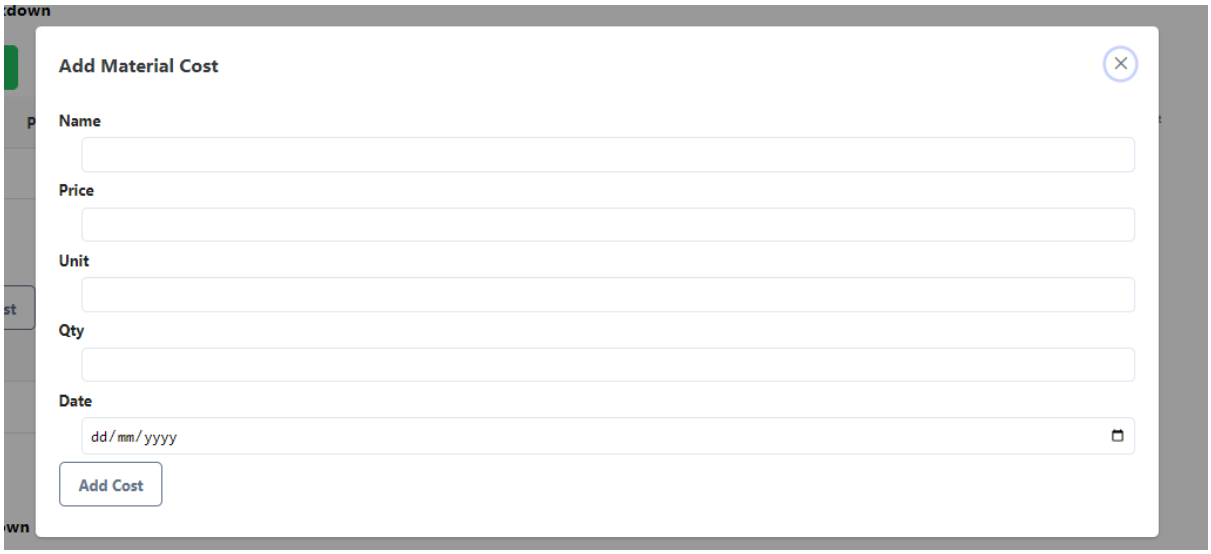
Step 4: The daily Cost Information

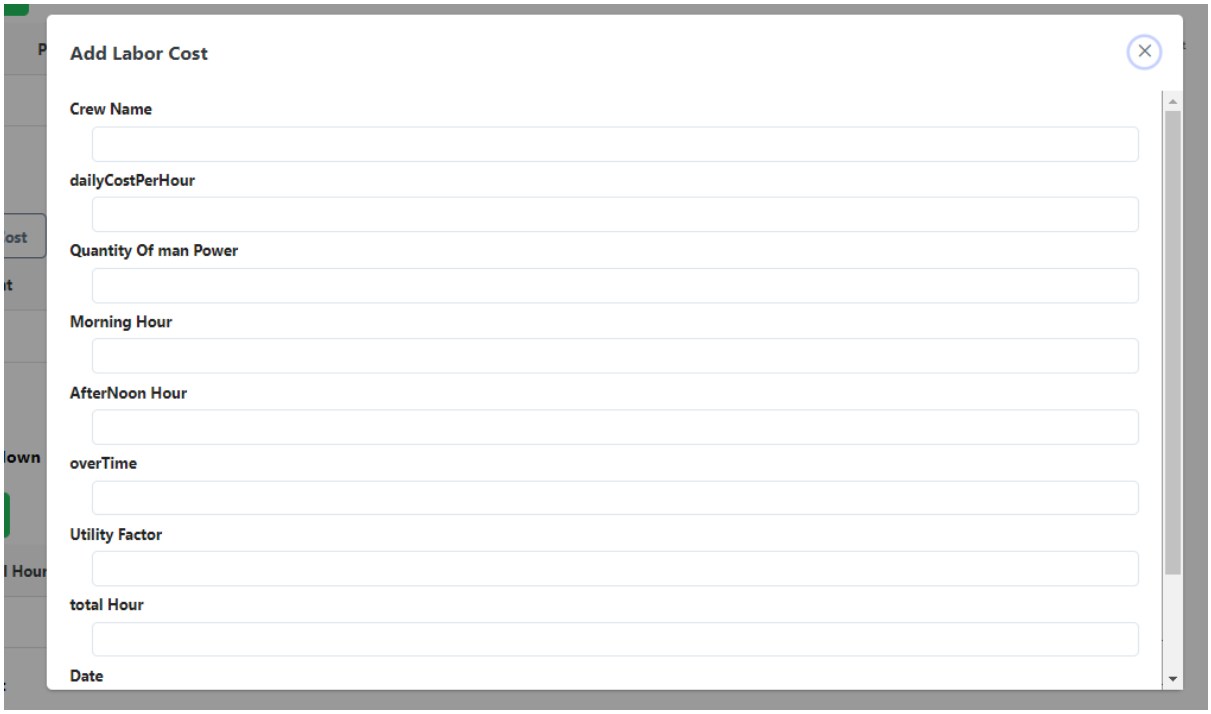
Once the sub activity is created the user can fill the actual cost information gathered from the site directly into the web based application in order to do that he/she right clicks on the sub activity click on the “View Report” and inserts the information.

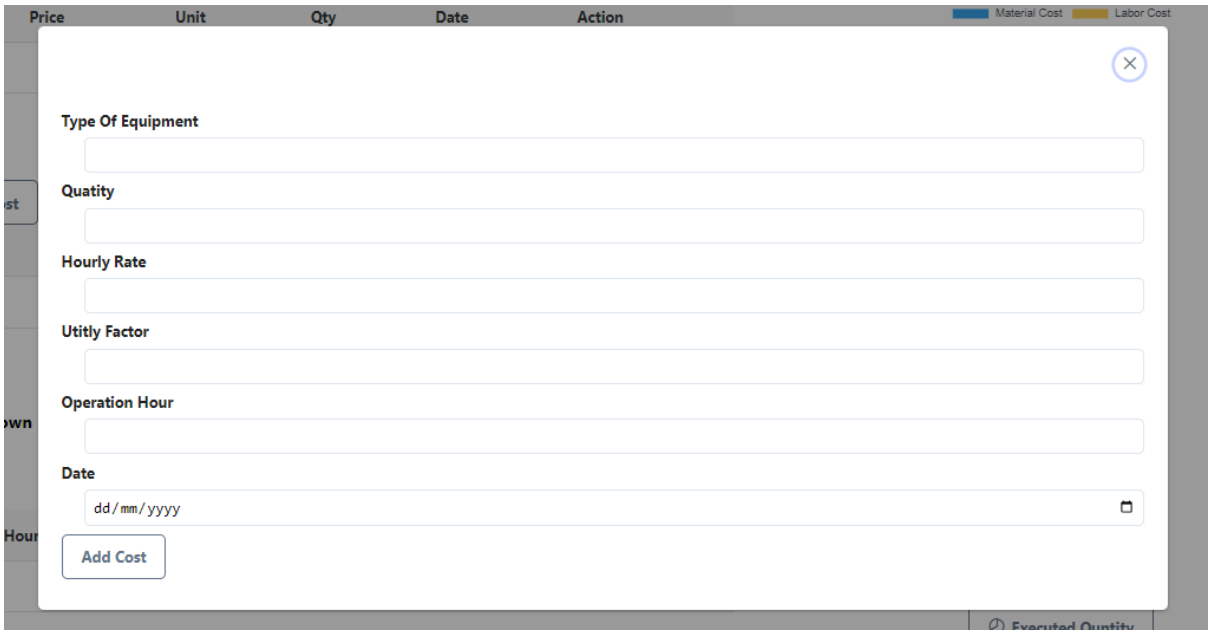




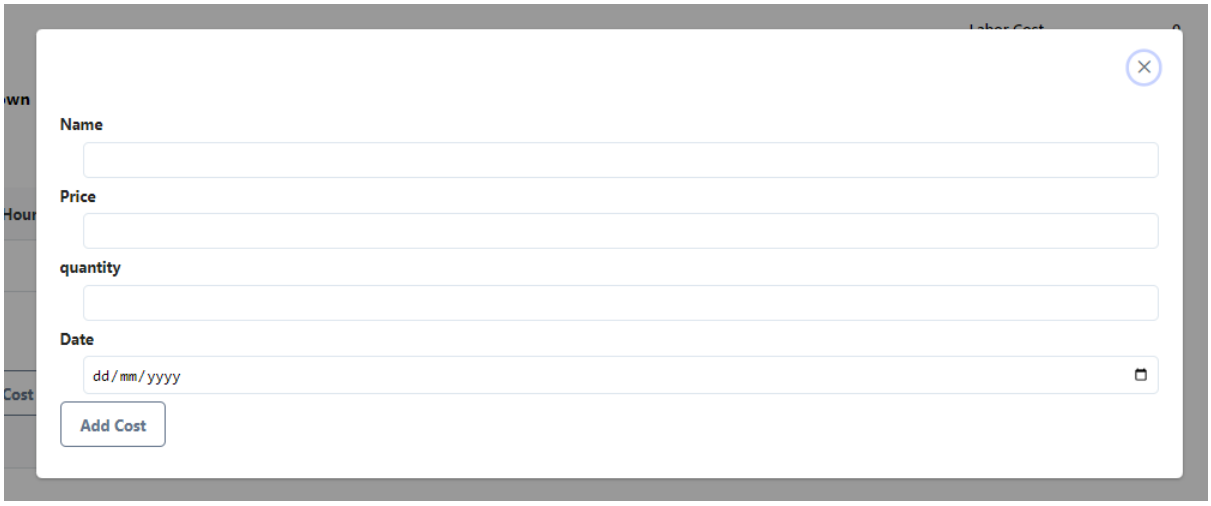
Cost information such as the material, labor, equipment and subcontract costs are added here by clicking on each add button it opens a table for inserting the necessary cost information in addition calendar is provided to insert cost information each sub activity. Executed quantity is button is also provided to insert the executed quantity daily.

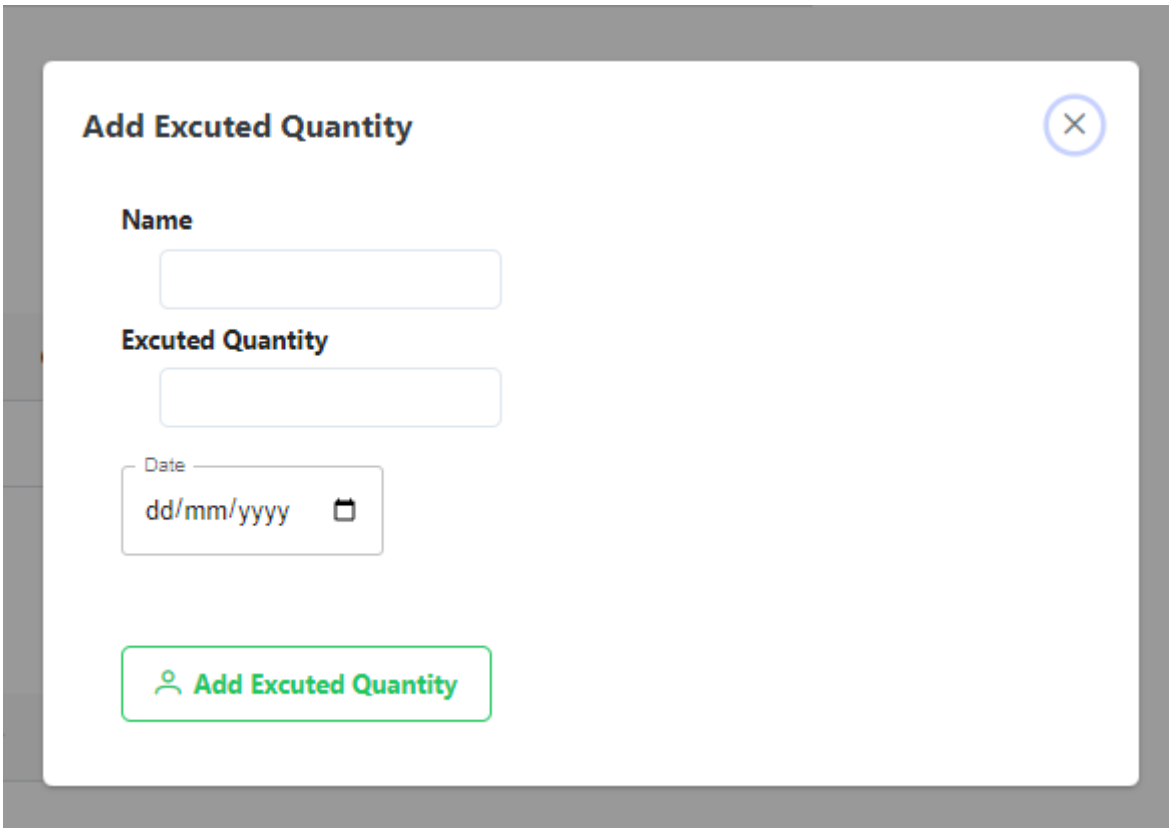



Add Labor Cost
Crew Name
dailyCostPerHour
Quantity Of man Power
Morning Hour
AfterNoon Hour
overTime
Utility Factor
total Hour
Date


Price
Unit
Qty
Date
Action
Material Cost
Labor Cost
Type Of Equipment
Quatity
Hourly Rate
Utitly Factor
Operation Hour
Date
dd/mm/yyyy
Add Cost

Add subcontract cost.



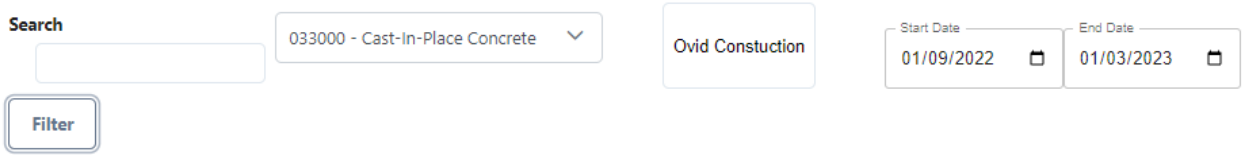


The user can insert the necessary cost information by clicking on each button or saying Add.

Step 5: The Reports

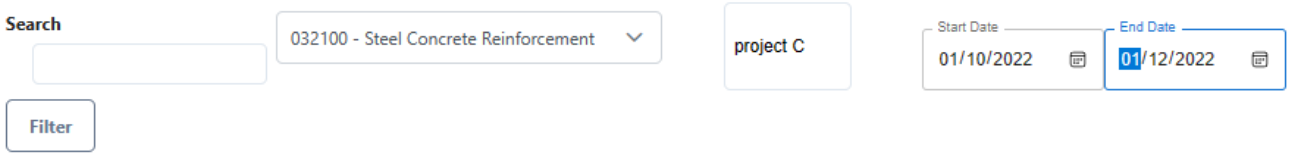
Once the user put all the cost information the system, the system automatically prepares different reports. The user gets back to the main window where he/she can see the report buttons on the top on the main window. By clicking on the reporting type he/ she wants it provides a different page for selecting the cost code, the project and the range of reporting dates.

For example, if you select any of the listed report once you click on it provides a new page asking the cost code the project name, the sub activity cost code and the reporting dates or range you want to see. Automatically it gives the need reports as shown in the samples below.



Budget Report

Activity	Sub-Activity	Budgeted Quatity ToDateBQ	Executed AmountAQ	Labor CostLC	Material CostMC	Equipment CostEC	Subcontract CostSC	Total Direct CostDC	Total Cost To DateTC	Actual Unit CostAUC
2nd basement column	2nd basement column concrete	61	55	9550	660000	16488	0	686038	926151.3	16839.11
1st Basement slab	1st Basement slab concrete work	1054	1053.37	12700	1581000	28854	0	1622554	2190447.9	2079.47
1st basement beam	1st basement beam concrete	66	64.71	1975	715000	8244	0	725219	979045.65	15129.74
1st basement stair case	1st basement stair case concrete	3	3	0	13911	0	0	13911	18779.85	6259.95
2nd basement shear wall	2nd basement shear wall concrete	74	14.5	0	172500	0	0	172500	232875	16060.34



Cost Summary Report

Activity	Sub-Activity	Executed AmountAQ	Actual CostAC(Birr)	Actual Unit CostAUC	Quantity To Complete	Cost To Complete(Birr)	Forecast To Complete	Complete Quantity(%)	Complete Cost(%)	Variance	Action
Ground floor column	Ground floor column Reinforcement	2500	109311.88	56.84	0	0	109311.88	100	55.00000000000001	-90688.12	
mezanine flr beam	mezanine flr beam reinforcement	1500	77633.91	67.28	0	0	77633.91	100	65	-42366.09	
Mezanine floor slab	Mezanine floor slab reinforcement	24800	1211737.42	63.52	200	12704	1224441.42	99	61	-775558.58	