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DEVELOPING A MODEL FOR ENHANCING COST MONITORING AND CONTROL IN THE CONSTRUCTION FIRMS

Mohamed Adel Elsayed[1], Ahmed Abdel Moamen Khalil[2],

Shady Ahmed Mohammed[3], Tarek Mahmoud Attia[4]

[1]Engineer and Master's Student, Civil Engineering Department, Faculty of Engineering at Shobra, Benha University, Egypt. mohamed.adel.m.elsayed@gmail.com,

[2]Assistant Professor, Civil Engineering Department, Faculty of Engineering at Shobra, Benha University, Egypt. ahmed.khalil@feng.bu.edu.eg

[3]Lecturer, Civil Engineering Department, Faculty of Engineering at Shobra, Benha University, Egypt. shady.ahmed@feng.bu.edu.eg

[4]Professor and Director, Construction Engineering and Project Management Research Institute, Housing and Building National Research Center, Egypt. tarek.attia@hbrc.edu.eg

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ABSTRACT

Construction cost is one of the most important constrain for the success of the project. Cost monitoring and control in the construction firm is one of the significant processes of cost management practices that are required for the survival and growth of every construction firm. A lack of sufficient construction cost monitoring and control by construction firms contributes largely to construction cost overruns. Despite all the efforts made to control cost, some construction firms still continue to unrealize their expected profit margin at the end of the project completion, due to the fact that many construction firms' cost control systems and models are not sufficient. This study provides a model of processes for enhancing cost monitoring and control in construction firms by making the integration of cost estimation and cost control and helping the managers to evaluate the performance and control resource consumption through output reports like cost report, productivity report, and wastage report. The model shows the inputs required as cost estimation for different project resources, and processing required to make cost baseline, actual cost, and coding system.

Keywords: Cost Control, Cost Management, Productivity, Quantity Surveying, Resource Consumption Optimization, Material Wastage.

1 INTRODUCTION

The construction industry is one of the most important industries that have a great impact on the nation's economy.

The main goal of project management is to ensure the projects close on time, within budget, and attain other project objectives.

Among the success parameters of a construction project namely: cost, quality, and time, the project cost was the most important within the construction industry [1]. Money is always vital and critical in construction projects.

According to [2], control is the process of monitoring; evaluating, and comparing the planned results with actual results to evaluate the status of the project cost. Research defined monitoring as a process of keeping track and checking systematically all the project activities. Cost control is used to monitor, evaluate, and most important increase the efficiency of specific areas within their operations [3]. Cost control is not only monitoring costs and recording data but also analyzing the data for taking corrective action [4]. According to [5], when construction work starts, the budgeted cost of the construction project is the baseline for the cost control team to use to check and control the construction costs. Cost control of a project involves measuring and collecting the cost record of a project and the work progress, and it also involves the comparison of actual progress with planning to determine variances [6].

Effective cost monitoring and control has received much attention in the construction industry due to excessive cost escalation and little profit margin of some construction firms [7]. Active cost monitoring and control process enables the contractor to achieve an acceptable profit on construction activities [1].

A lack of sufficient construction cost monitoring and control by construction firms contributes largely to construction cost overruns [8]. Cost monitoring and control have not been taken seriously by smaller and some medium-sized construction firms [9]. It is important for construction firms to use an effective cost control procedure during the post-contract stage of projects to keep the planned cost within the building budget [10].

Various resources such as labor, material, equipment, and subcontractors have a direct impact on the construction cost. This effect needs to be monitored and controlled by the construction firms in an effective and manageable way. Resource inputs at the project site which produce outputs in the form of construction work involve men, materials, machinery, and money. The success of a project depends on the performance of those input resources when monitoring and controlling cost [11].

The definition of cost control can be the comparison of the actual against the budgeted and concerned with calculating variances from the cost budget or baseline [8]. Cost control aims to manage the delivery of the project within the approved construction budget cost [12].

The practice helps construction firms to eliminate or reduce unnecessary waste of resources in the execution of their projects [5]. There are very few studies on practices for enhancing project monitoring and control in practice [13]. Many cost monitoring and control methods have been used in the past in different firms and have not been efficient. The cost itself is a major difficulty in operating a detailed cost monitoring and control model [14].

Regular cost reporting presents the best possible estimate of the established project cost to date, the expected final cost of the project [15]. The construction management analyzes the reasons for any variance [16]. According to [17], without monitoring and controlling the actual cost while the project is in progress, the completion of the project within the budget will not be possible.

An understanding of the various aspect of cost control principles is vital to enable managers to effectively prepare their cost control and in the development of future forecasting techniques for effective project delivery [18].

The final point to make attention to identify the most effective tool out of the identified proper tools for the project delivery [6]. The impact of cost monitoring and control in construction firms has been becoming a vital research area in the current industrial community [6]. Developing a model for enhancing cost monitoring and control in construction firms is a vital and required matter [5].

2 Research Problem

A lack of sufficient construction cost monitoring and control by construction firms contributes largely to construction cost overruns. Despite all the efforts made to control cost, some construction firms still continue to unrealize their expected profit margin at the end of the project completion, due to the fact that many construction firms' cost control models are not sufficient.

3 Research Objectives

The main goal of this study is to develop a model to monitor and control the project cost in construction firms using a tool (Microsoft Excel spreadsheet) by making the integration of cost estimation and cost control and helping the managers to evaluate the performance and control resource consumption through output reports like cost report, productivity report and, wastage report.

4 Research Methodology

Develop a model to monitor and control the construction cost in the construction firms using a tool (Microsoft Excel spreadsheet) showing the inputs requires as cost estimation for different project

resources, processing required to make cost baseline, actual cost, and coding system, and reports outputs helping the monitoring and the control of the construction project cost, and validate the model by a case study.

5 Literature Review

According to [19], the construction phase has the greatest ability to increase the planned budgeted cost, which assures the importance of cost control as shown in Figure 1.

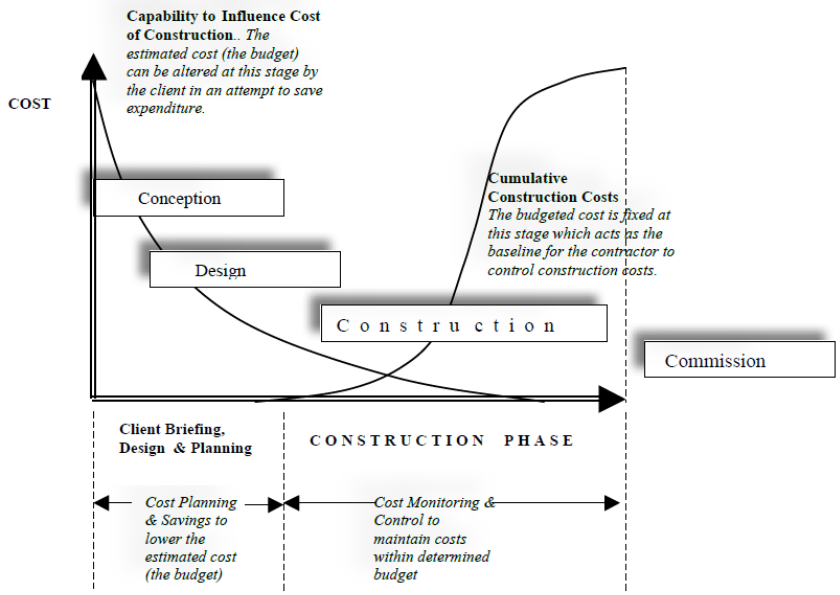

Figure 1: Capability to influence the cost of projects.

Source: Cost & Value Management in Projects [20].

Most of the literature has documented that recent construction projects experience failures since they became unsuccessful to manage and control the cost during the project execution stage [6]. Hence, monitoring and controlling cost in construction firms is one of the most important challenges in construction management [21]. It is very important to monitor and control the construction cost during the construction period of construction projects. Construction firms should pay attention to the problems of construction cost during the project construction [22].

According to [23], construction cost control of a project includes calculating and collecting the cost data of a project and the work progress. It also includes the comparison of actual progress with the planning.

According to [24], a schematic representation of the cost monitoring and control model was given as shown in Figure 2.

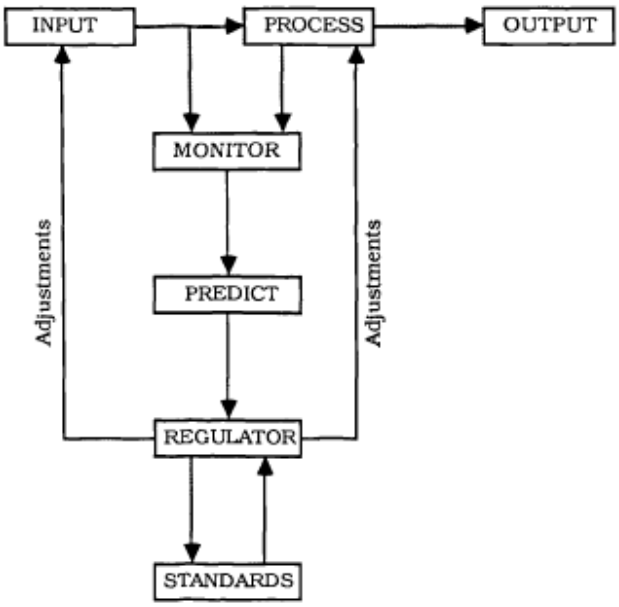

Figure 2: Schematic cost monitoring and control model

According to [15], a summary of the cost control model consisting of two sections: cost modeling project activities and monitoring and control project activities was provided as shown in Figure 3.

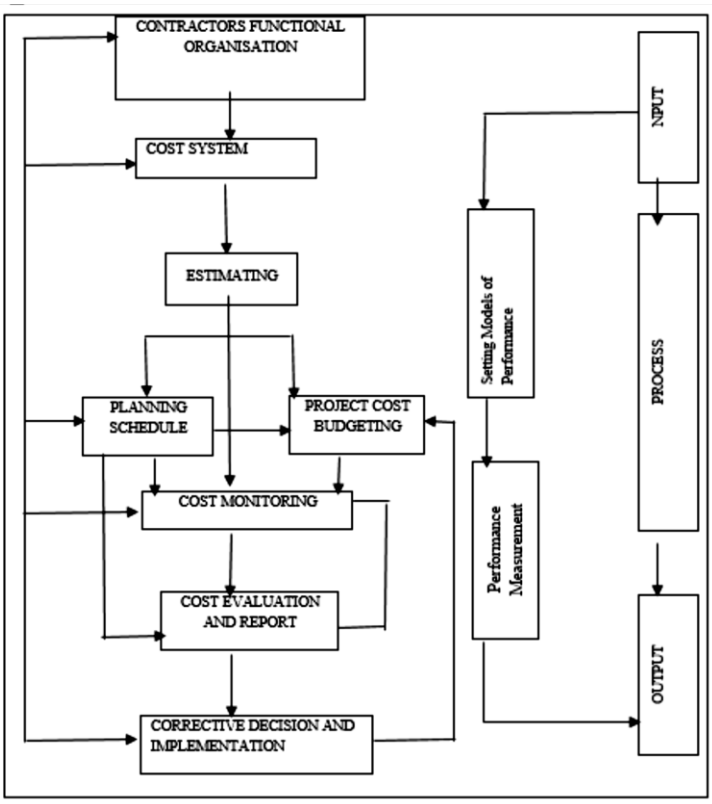

Figure 3: Cost control model

The contractor at this stage of construction is faced with one of the most difficult tasks in construction management such as monitoring and controlling construction project cost [19].

According to [25], The model should help in detecting variance between the plan and the actual implementation.

According to [26], a cost control process consisting of three sections bidding, construction, and termination was provided as shown in Figures 4 and 5.

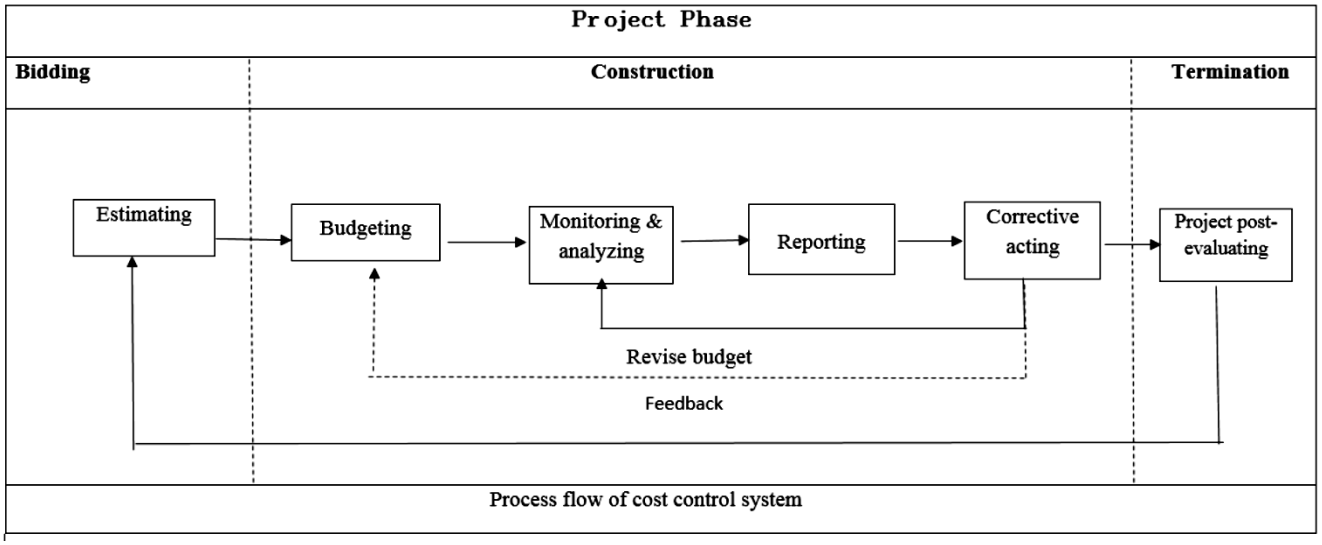

Figure 4: Cost control process

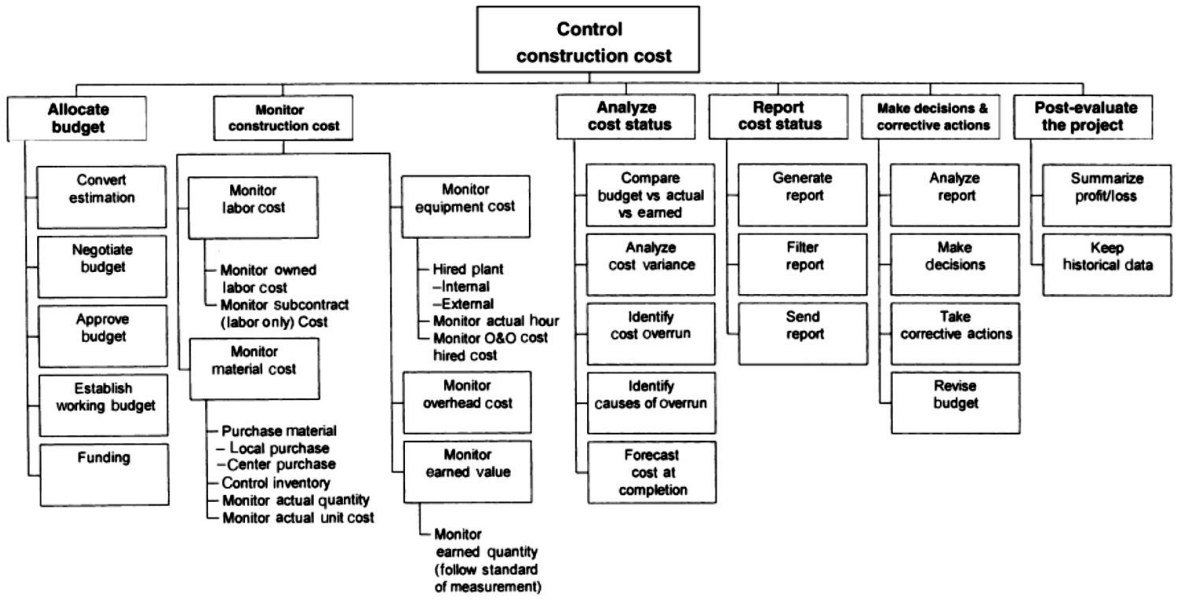

Figure 5: Cost control breakdown

According to [27], during the construction stage, deviation of the plan of the project cost will occur. Although this fact, construction projects should have a monitoring and control cycle as follows, to complete the project within the required budget cost:

- Make a plan.
- Implement the plan.
- Record the actual output and analyze it.

- Report the actual parameters, the planned parameters, and their variance.
- Take corrective action on the variance.

A cost system model for cost management as described in [28] is a structure comprising a set of techniques and processes required to set, plan, estimate, budget, control, and report project costs. Achieving effective project cost monitoring and control is not a simple process but includes the proper consideration of the choice methods of the process and how effectively they are implemented is vital to produce special outcomes. However, there is a systematic way in which the techniques and process need to relate to an eventual successful outcome. This structure can be referred to as the project cost monitoring and control model.

According to [29], cost monitoring and control report using Microsoft Excel to compare with the budgeted cost and the variances and by using the data from bill of quantity to monitor and control various resources like labor, material, equipment, subcontractors' work, and indirect was provided as shown in Figure 6.

Company's name, address and logo																
DAILY, WEEKLY, MONTHLY BUDGET REPORT																
Project information: project name, contract number, client, consultants																
	LABOUR				PLANT			MATERIALS			SUB-CONTRACT		MISC. EXPENSES			
RESOURCES	Top level management staff	Middle level management staff	Lower level management staff	General workers	Plant 1	Plant 2	Plant 3	Material 1	Material 2	Material 3	Nominated supplier items	Nominated work list	overheads	Other expenses		
No. of hrs	1	1	1	1	1	1	1	1	1	1	1				Rate	Amount
TOTAL SITE COST PER DAY, WEEK OR MONTH																

Figure 6: Cost monitoring and control report

According to [5], the cost control practice from the perspective of construction firms was explained. When construction starts the budget which is a conversion from the estimate acts as the baseline for the contractor to control costs. Any client-directed variations to the project at this stage

will result in essential cost increases for the client. The responsibility of the contractor to the client is to execute the project according to the specifications, cost, and schedule.

With maximum profit in mind, the contractor will have to turn to cost monitoring and control for assistance. Construction firms need to continuously improve their efficiency in cost control [30].

According to [3], the technique and process for cost monitoring and control used in the construction firms were investigated as the following:

- Work with programmers by using the progress of the project schedule and financial performance.
- Inspection of works by comparing the work done by inspection with the budget.
- Evaluation of work carried out by comparing the quantification of works with the bill of quantities.

According to [13], Microsoft Excel is an important software for project cost control.

According to [14], the project cost control systems should include estimation, monitoring, project reporting, and forecasting. Research presented a model which was developed in Microsoft Excel to show the project cost monitoring and control in the construction firms as shown in Figure 7.

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	Direct cost	
First	01	Material
	02	Equipment
	03	Labor
	04	Subcontractor
	Sum of direct cost	
Second	Tax	
	Indirect cost	
	First + second	
Third	Indirect cost	
Fourth	Total cost	

Figure 7: Cost details for the construction project

According to [31], Microsoft excel can be used to track construction projects.

According to [32], a conceptual model for a cost management system in low-cost housing projects to identify the potential techniques and process approaches for effective cost management practice at the predesign, design, and construction stages was provided as shown in Figures 8 and 9.

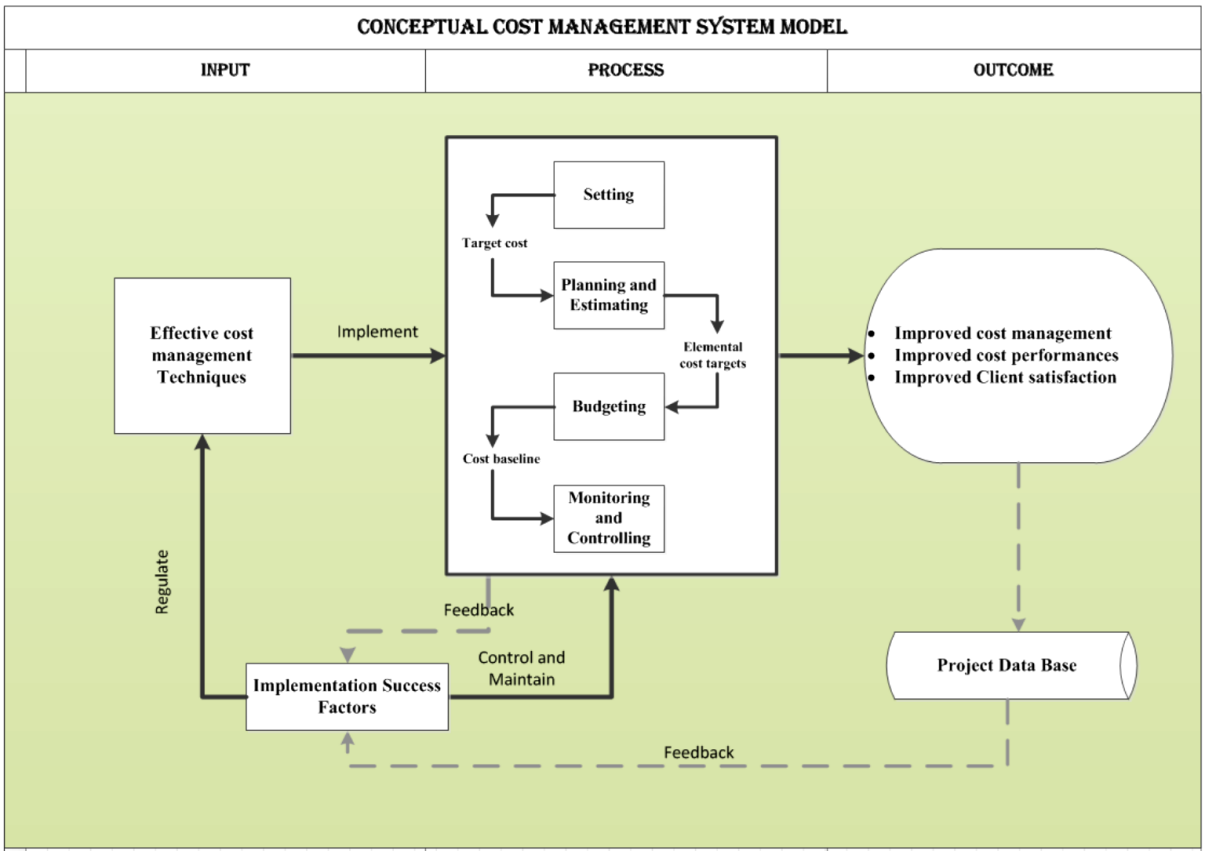

Figure 8: Conceptual model

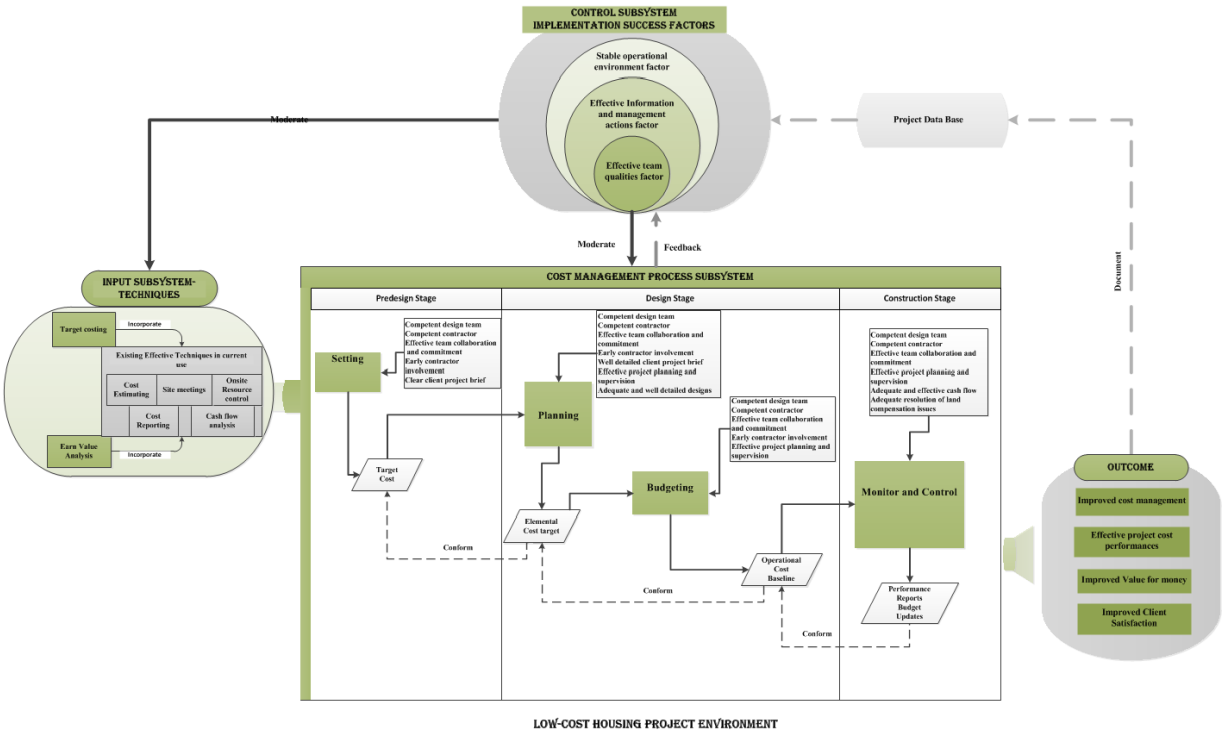

Figure 9: Conceptual model for cost management system in low-cost housing projects

According to [33], project cost reports to be used for cost monitoring and control in the construction firms were investigated as shown in Figure 10.

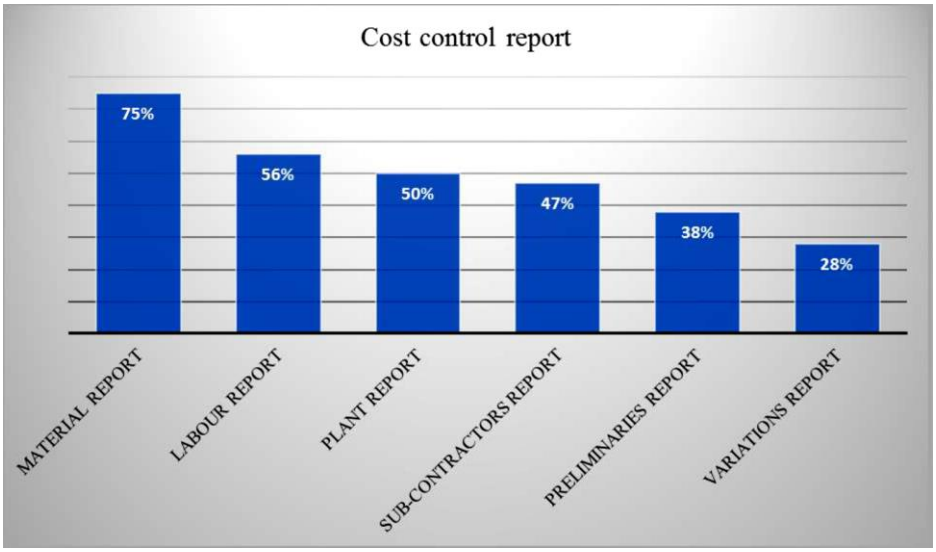

Figure 10: Cost control reports

According to [34], Microsoft Excel is an important tool for control. Also, some methods of cost control were identified as the following:

- Unit Costing by periodic assessment of each item in the bill of quantities.
- By overall profit or loss by assessment of the status of the project at the completion date.
- Profit/loss at valuation dates by assessment at each payment.
- Activity-Based Ratio by Periodic assessment of each project activity.
- Leading Parameter by Periodic assessment of the main item.

According to [35], project cost monitoring and control is a cyclic process including the comparison of actual to planned performance, estimates at completion, and corrective actions based on such forecasts. He provided an overall organizational cost system as shown in Figure 11.

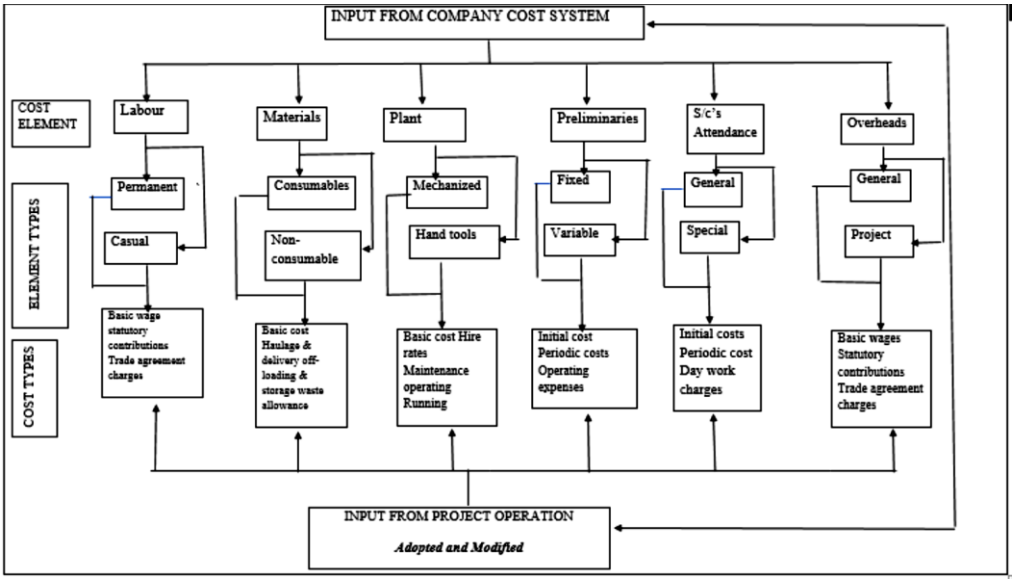

Figure 11: Elements of cost control system. Source: [36] adopted and modified

According to [37], [38], cost monitoring and control practice during construction is a challenge in the construction industry.

6 Model

A model is provided in this study. This model's main objective is for enhancing cost monitoring and control in construction firms. This model consists of inputs, processing and outputs. the inputs required as cost estimation for different project resources, processing required to make cost baseline, actual cost, and coding system, and reports outputs with the clear interface as clarified in Figure 12. This model introduces many reports, which are the model's outputs. Reports are the sheets that show data and information in an organized way for the users. The content of these reports will be clarified in the outputs section.

A building in Egypt located in the 6th of October city is used as a case study to validate and evaluate the power of the model for helping the construction firm in cost monitoring and control. The data of the building was used in the model as following figures.

6.1 Definitions

This section clarifies the most important definition for many items that are used in the model.

- Bill Of Quantity "BOQ": a tendering document to define the quality and quantity of work required from the construction firm to complete a project and also provides the measured quantities of work that are identified on the project drawings and specifications.
- Cost Breakdown "CBS": is the breakdown of the cost into its elements such as labor, material, and equipment, …
- Direct Cost: Those resources are spent slowly to complete the activity or asset. Thus, the direct cost of a foundation for a house includes trenching for the footings, the wooden forms, the concrete, and the labor to place and finish the concrete. Directly attributable to project work. It consists of labor, material, equipment, and subcontractor cost.
- Indirect Cost: Those resources spent to complete the general project and not allocated to a specific activity or in BOQ. It consists of general overhead containing head office overhead and site overhead containing staff expenses, site installation, water, electricity, safety, …
- Markup: The project cost is marked up to cover risk, contingency, profit and taxes.
- Production Rate: the quantity of total production produced in a unit of time. It is very important in the cost estimation of labor and calculating duration.
- Productivity: the ratio between the total output and the total inputs.

- Consumption Rate: the usage rate of the cost element. It can be got from the historical data, the construction firm rates, and the element data sheet from the vendors.
- Coding System: a system that defines any cost item by unique code to help in collecting cost data together.
- Cost Baseline: this is the approved budget for the project.
- Transaction Report: the report shows all of the actual cost transactions by account.
- Cost Report: the main report to calculate the budget, actual, estimate, forecast and variance to evaluate project status.
- Purchase Order "PO": a document for purchasing material from vendors.
- Contract: an agreement between two parties to finish a specific work or service.

6.2 Inputs

Inputs contain the required data from the cost estimation "tender" stage as the following:

- Bill Of Quantity "BOQ" as clarified in Figure 13.
- Cost Breakdown "CBS" as clarified in Figure 14.
- Resources Cost as clarified in Figure 15.
- Labor Production Rate as clarified in Figure 16.
- Consumption Rate as clarified in Figure 17.
- CBS-Equipment as clarified in Figure 18.
- CBS-Other Indirect Cost as clarified in Figure 19.
- CBS-Financial & Markup as clarified in Figure 20.
- Summary as clarified in Figure 21.
- Summary CBS as clarified in Figure 22.

6.3 Processing

Processing consists of four parts as the following:

1. Coding System contains Cost Coding used as clarified in Figure 23.
2. The Cost Baseline Budget at Completion "BAC" contains the following:
    - BAC-Direct Cost as clarified in Figure 24.
    - BAC-Equipment as clarified in Figure 25.
    - BAC-Indirect Cost as clarified in Figure 26.
    - BAC-Financial & Mark-up as clarified in Figure 27.
3. Actual Cost "AC" contains AC-Transaction Report as clarified in Figure 28.
4. Estimate At Completion "EAC" contains the following:

- EAC-Labor as clarified in Figure 29.
- EAC-Equipment as clarified in Figure 30.
- EAC-Material as clarified in Figure 31.
- EAC-Subcontractor as clarified in Figure 32.
- EAC-Staff as clarified in Figure 33.

6.4 Outputs

Outputs contain many reports for monitoring and controlling project cost. These reports are divided into six categories as the following:

1. Main General Report is Cost Report as clarified in Figure 34.
2. Labor monitoring and control contain the following reports:
    - Worker Plan vs Actual as clarified in Figure 35.
    - Productivity Plan vs Actual as clarified in Figure 36.
    - Production Rate Plan vs Actual as clarified in Figure 37.
3. Staff monitoring and control contain the following report:
    - Staff Plan vs Actual as clarified in Figure 38.
4. Material monitoring and control contain the following reports:
    - Material Quantity Surveying vs Purchase Orders as clarified in Figure 39.
    - Wastage Plan vs Actual as clarified in Figure 40.
5. Subcontractor monitoring and control contain the following report:
    - S.C. Quantity Surveying vs Contracts as clarified in Figure 41.
6. Equipment monitoring and control contain the following report:
    - Equipment Plan vs Actual as clarified in Figure 42.

6.5 Model Formats and Reports

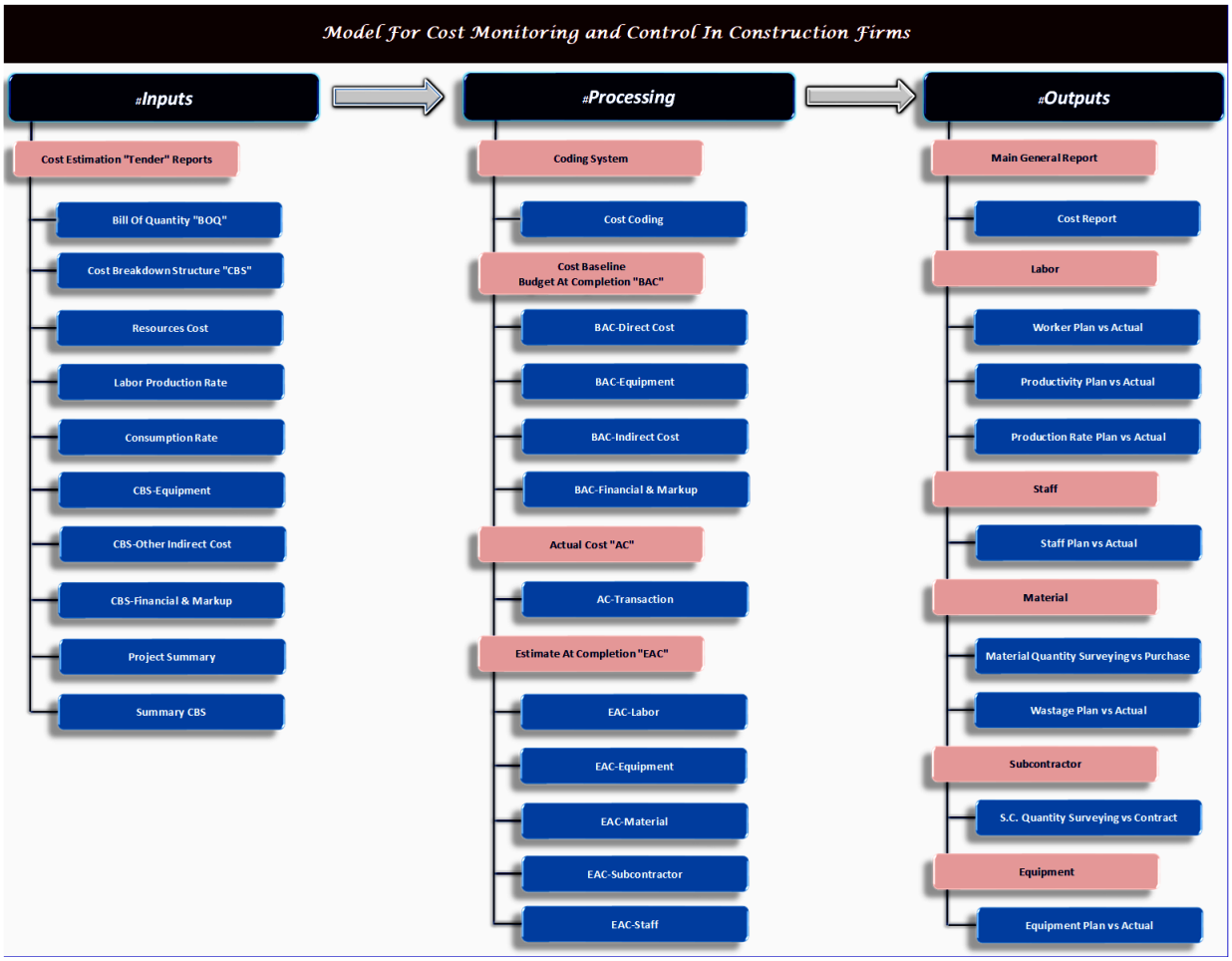

Figure 12: The first user interface for the model.

Figure 12: The first user interface for the model shows the whole model inputs, processing and output reports divided by categories linked to each other.

Item No.	Description	Unit	Total Qty.	Unit Rate	Total
	EARTHWORKS				
A	Excavation in ordinary soil	m³	**600**	28	16,768
B	Backfill with compacted sand	m³	**200**	49	9,782
	CONCRETE				
C	Supply and cast plain concrete with average compressive strength 200 kg/cm2 at 28 days, with cement ratio of 250 kg/m3.	m³	**500**	1,237	618,335
D	Reinforced concrete Fcu=250 kg/cm2 according to specifications..	m³	**800**	3,270	2,615,872
	MASONRY				
E	Solid cement brick walls 25cm thick, Cement 300kg/m3	m³	**300**	720	215,913
F	Solid cement brick walls 12cm thick, Cement 300kg/m3	m²	**4000**	88	350,106
	PLASTER				
G	Internal walls plaster, Cement 350kg/m3	m²	**6000**	33	196,407
	TILES				
H	ceramic tiles, Cement 300kg/m3	m²	**3500**	173	605,556
TOTAL					**4,628,739.001**

Figure 13: Bill of quantity "BOQ".

Figure 13: Bill of Quantity "BOQ" is a document that contains the project items, quantities, unit rates and total amounts. Various construction items are chosen to clarify and validate the model.

Project Name						
Company Name			Date			
	Item Description					
BOQ ITEM DESCRIPTION:	Excavation in ordinary soil					
BOQ ITEM UNIT:	m3					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
SUB-CONTRACTORS						
	Excavation Subcontractor	M3	20.00	1.00	1.00	20.00
	TOTAL SUB-CONTRACTORS COST					20.00
			ITEM UNIT DIRECT COST:			20.00
BOQ ITEM DESCRIPTION:	Backfill with compacted sand					
BOQ ITEM UNIT:	m3					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
SUB-CONTRACTORS						
	Backfilling Subcontractor	M3	35.00	1.00	1.00	35.00
	TOTAL SUB-CONTRACTORS COST					35.00
			ITEM UNIT DIRECT COST:			35.00
BOQ ITEM DESCRIPTION:	Supply and cast plain concrete with average compressive strength 200 kg/cm2 at 28 days, with cement ratio of 250 kg/m3.					
BOQ ITEM UNIT:	m3					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
	Plain Concrete	M3	700.00	1.00	1.05	735.00
	TOTAL MATERIALS COST					735.00
SUB-CONTRACTORS						
	PC Subcontractor	M3	150.00	1.00	1.00	150.00
	TOTAL SUB-CONTRACTORS COST					150.00
			ITEM UNIT DIRECT COST:			885.00
BOQ ITEM DESCRIPTION:	Reinforced concrete Fcu=250 kg/cm2 for foundations according to specifications..					
BOQ ITEM UNIT:	m3					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
	Reinforcement Concrete	M3	800.00	1.00	1.05	840.00
	Reinforcement Rebar	Ton	10,000.00	0.10	1.05	1,050.00
	TOTAL MATERIALS COST					1,890.00
SUB-CONTRACTORS						
	RC Subcontractor	M3	450.00	1.00	1.00	450.00
	TOTAL SUB-CONTRACTORS COST					450.00
			ITEM UNIT DIRECT COST:			2,340.00

BOQ ITEM DESCRIPTION:	Solid cement brick walls 25cm thick					
BOQ ITEM UNIT:	m3					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
	Cement Bricks	1000	650.00	0.423	1.05	288.46
300kg/m3	Cement	Ton	900.00	0.07	1.05	67.82
	Sand	M3	70.00	0.24	1.05	17.58
	Water	M3	30.00	0.04	1.10	1.18
	TOTAL MATERIALS COST					**375.05**
LABORS						
	Mason Technician+Mason Assistant+Morter Technician+Unskilled labor	day	350.00	0.40	1	140.00
	TOTAL DIRECT LABORS COST					**140.00**
			ITEM UNIT DIRECT COST:			**515.05**

BOQ ITEM DESCRIPTION:	Solid cement brick walls 25cm thick					
BOQ ITEM UNIT:	m3					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
	Cement Bricks	1000	650.00	0.423	1.05	288.46
300kg/m3	Cement	Ton	900.00	0.07	1.05	67.82
	Sand	M3	70.00	0.24	1.05	17.58
	Water	M3	30.00	0.04	1.10	1.18
	TOTAL MATERIALS COST					**375.05**
SUB-CONTRACTORS						
	Bricks 25cm Subcontractor	m3	150.00	1.00	1.00	150.00
	TOTAL SUB-CONTRACTORS COST					**150.00**
			ITEM UNIT DIRECT COST:			**525.05**

BOQ ITEM DESCRIPTION:	Solid cement brick walls 12cm thick					
BOQ ITEM UNIT:	m2					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
	Cement Bricks	1000	650.00	0.055	1.05	37.50
300kg/m3	Cement	Ton	900.00	0.01	1.05	5.98
	Sand	M3	70.00	0.02	1.05	1.55
	Water	M3	30.00	0.003	1.10	0.10
	TOTAL MATERIALS COST					**45.14**
LABORS						
	Mason Technician+Mason Assistant+Morter Technician+Unskilled labor	day	350.00	0.05	1	17.50
	TOTAL DIRECT LABORS COST					**17.50**
			ITEM UNIT DIRECT COST:			**62.64**

BOQ ITEM DESCRIPTION:	Solid cement brick walls 12cm thick					
BOQ ITEM UNIT:	m2					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
	Cement Bricks	1000	650.00	0.055	1.05	37.50
300kg/m3	Cement	Ton	900.00	0.006	1.05	5.98
	Sand	M3	70.00	0.021	1.05	1.55
	Water	M3	30.00	0.003	1.10	0.10
	TOTAL MATERIALS COST					**45.14**
SUB-CONTRACTORS						
	Bricks 12cm Subcontractor	m2	50.00	1.00	1.00	50.00
	TOTAL SUB-CONTRACTORS COST					**50.00**
			ITEM UNIT DIRECT COST:			**95.14**

BOQ ITEM DESCRIPTION:	Internal walls plaster					
BOQ ITEM UNIT:	m2					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
450kg/m3	Cement for Spatterdash	Ton	900.00	0.002	1.05	2.13
350kg/m3	Cement	Ton	900.00	0.01	1.05	6.62
	Sand	M3	70.00	0.03	1.05	1.84
	Water	M3	30.00	0.004	1.10	0.14
	TOTAL MATERIALS COST					10.72
LABORS						
	Plasterer+2Morter Technician+3Unskilled labor	day	470.00	0.03	1	12.70
	TOTAL DIRECT LABORS COST					12.70
			ITEM UNIT DIRECT COST:			23.43
BOQ ITEM DESCRIPTION:	Internal walls plaster					
BOQ ITEM UNIT:	m2					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
450kg/m3	Cement for Spatterdash	Ton	900.00	0.00	1.05	2.13
350kg/m3	Cement	Ton	900.00	0.01	1.05	6.62
	Sand	M3	70.00	0.03	1.05	1.84
	Water	M3	30.00	0.004	1.10	0.14
	TOTAL MATERIALS COST					8.60
SUB-CONTRACTORS						
	Plaster Subcontractor	m2	15.00	1.00	1.00	15.00
	TOTAL SUB-CONTRACTORS COST					15.00
			ITEM UNIT DIRECT COST:			23.60
BOQ ITEM DESCRIPTION:	ceramic tiles.					
BOQ ITEM UNIT:	m2					
		UNIT	UNIT RATE	COSUMPTION RATE	WASTE FACTOR	ITEM UNIT COST
MATERIALS						
	Ceramic	M3	90.00	1.00	1.05	94.50
300kg/m3	Cement	Ton	900.00	0.01	1.05	5.67
	Sand	M3	70.00	0.08	1.05	5.88
	Water	M3	30.00	0.003	1.10	0.10
	TOTAL MATERIALS COST					106.15
LABORS						
	Ceramic Technician+2Unskilled labor	day	265.00	0.07	1	17.67
	TOTAL DIRECT LABORS COST					17.67
			ITEM UNIT DIRECT COST:			123.82

Figure 14: Cost breakdown structure "CBS".

Figure 14: Cost Breakdown Structure "CBS" clarifies the bottom-up estimation method which is the most accurate approach to estimating the direct cost of project items. Direct cost is the cost directly attributable to project work. Direct cost consists of labor cost, material cost, equipment cost and subcontracting. Estimating individual work items with the lowest level of details and rolling-up the detailed cost to the higher levels for reporting and tracking.

Code	Item	Unit	Cost	
	Material			
MT	Water	m3	30	
MT	Sand	m3	70	
MT	Cement	Ton	900	
MT	Plain Concrete	m3	700	
MT	Reinforcement Concrete	m3	800	
MT	Reinforcement Rebar	ton	10000	
MT	Cement Bricks	1000	650	
MT	Ceramic	m2	90	
	Subcontractor			
SC	PC Subcontractor	m3	150	
SC	RC Subcontractor	m3	450	
SC	Bricks 12cm Subcontractor	m2	50	
SC	Bricks 25cm Subcontractor	m3	150	
SC	Bitumin Subcontractor	m2	25	
SC	Plaster Subcontractor	m2	15	
SC	Ceramic Subcontractor	m2	25	
SC	Excavation Subcontractor	m3	20	
SC	Backfilling Subcontractor	m3	35	
	Labors			
LR	Mason Technician	Day	130	
LR	Mason Assistant	Day	80	
LR	Morter Technician	Day	70	
LR	Plasterer	Day	120	
LR	Ceramic Technician	Day	125	
LR	Unskilled labor	Day	70	
	Labor Production Rate			
	Masonry works			
	Mason Technician+Mason Assistant+Morter Technician+Unskilled labor	m3/ Day	2.5	8hr/day
	Mason Technician+Mason Assistant+Morter Technician+Unskilled labor	m2/ Day	20	8hr/day
	Plaster works			
	Plasterer+2Morter Technician+3Unskilled labor	m2/ Day	37	8hr/day
	Ceramic works			
	Ceramic Technician+2Unskilled labor	m2/ Day	15	8hr/day

Figure 15: Resources cost.

Figure 15: Resources Cost is a sheet to put the amount of breakdown cost elements used in CBS.

Masonry works	
Mason Technician+Mason Assistant+Morter Technician+Unskilled labor	- P.R = 2.5m3/ Day
Mason Technician+Mason Assistant+Morter Technician+Unskilled labor	- P.R = 20m2/ Day
Plaster works	
Plasterer+2 Morter Technician+3 Unskilled labor	- P.R = 37m2/ Day
Ceramic works	
Ceramic Technician+2 Unskilled labor	- P.R = 15 m2/ Day

Figure 16: Labor production rate.

Figure 16: Labor Production Rate shows the quantity of total production produced by specific labor crews in the unit of time.

$$Production\ Rate = Output/Time \qquad (1)$$

Masonry works			
Masonry solid 25*12*6 - m3 25cm	1000	0.423	1/(0.26*0.13*0.07)"Brick Volume+1cm morter"/1000
Morter Volume	m3	0.24	1-(423"Bricks No."*1000*(0.25*0.12*0.06)"Brick Volume")
Plasterer+2Morter Technician+3Unskilled labor - P.R = 2.5m3/ Day	m3	0.40	1/Production Rate
Masonry solid 25*12*6 - m2 12cm	1000	0.055	
Morter Volume	m3	0.021	
Plasterer+2Morter Technician+3Unskilled labor - P.R = 20m2/ Day	m2	0.05	
Morter (Bricks and Ceramic)	m3	1	
Cement 300kg	Ton	0.300	(300/1000)*Morter Volume
Sand	M3	1.000	1**Morter Volume
Water	M3	0.150	0.5 Cement "W/C Ratio=0.5"
Plaster works			Plaster Work Thickness = "0.5cm" Thickness of Spatterdash + Main Plaster Thickness "2cm"
Morter		1	
Cement 450kg	Ton	0.450	
Cement 350kg	Ton	0.350	
Sand	M3	1.000	
Water	M3	0.175	
Thickness of Spatterdash	m2	0.005	
Main Plaster Thickness	m2	0.02	
Plasterer+2Morter Technician+3Unskilled labor - P.R = 37m2/ Day	m2	0.027	
Ceramic works			
Sand Thickness under ceramic	m2	0.08	Sand Thickness under ceramic = 6cm Sand + 2cm Morter
Morter Thickness under ceramic	m2	0.02	
Ceramic Technician+2Unskilled labor - P.R = 15 m2/ Day	m2	0.067	

Figure 17: Consumption rate.

Figure 17: Consumption Rate shows the usage rate of the material used. Consumption Rate can be got from the construction firm, material data sheet, encyclopedias or calculated.

	Equipment	Hour Rate	Months	Hrs	TOTAL
1	Loader	180.0	6.0	1248.0	224,640
2	Forklift	75.0	2.0	416.0	31,200
3	Generator	150.0	6.0	1248.0	187,200
	Total				**443,040**

Figure 18: CBS-Equipment.

Figure 18: CBS-Equipment is the cost breakdown of the equipment. By knowing the hourly rate of the equipment and planned total hours, getting the equipment amount.

	Staff	Rate	Months	Hrs	TOTAL
1	Project Manager	12000.0	6.0	1248.0	72,000
2	Site Engineer	5500.0	6.0	1248.0	33,000
3	Technical Office Engineer	5000.0	6.0	1248.0	30,000
4	Surveyor	4500.0	5.0	1040.0	22,500
5	HSE Engineer	4000.0	6.0	1248.0	24,000
6	Store Keeper	3500.0	6.0	1248.0	21,000
	Total	**34500**			**202,500**
	Other Indirect Cost				
1	Site offices and other office supplies				35,000
2	Safety Expenses				10,000
3	Security Expenses	1500	6		9,000
	Total				**54,000**

Figure 19: CBS-Other indirect cost.

Figure 19: CBS-Other Indirect Cost shows the cost breakdown of the staff salaries and other indirect costs. The indirect cost may be a calculated percentage or calculated amount.

	Financial and Markup			Total Cost Direct + Indirect	Amount
1	Bonds Costs	0.75%	of total price	4,012,011	30,317
2	Insurance	2.00%	of total price	4,012,011	81,878
3	Risk and Contingency	1.00%	of total price	4,124,206	41,659
4	Profit	10.00%	of total price	4,165,865	462,874
	Total				**616,728**

Figure 20: CBS-Financial & Markup.

Figure 20: CBS-Financial & Markup shows the cost breakdown of bonds, insurance, risk and profit. The amount is calculated by using a specific percentage of the total project price. Although the total project price is not defined yet, the amount will be calculated by using the following equation:

$$Price = Cost\ (100\% / (100\% - Markup) \qquad (2)$$

SN	Item	Total Amount
1	Direct Cost	3,312,471
2	Indirect Cost	811,735
3	Risk and Contingency	41,659
4	Profit	462,874
	Total	**4,628,739**
	Multiplier to Direct Cost	1.40

Figure 21: Summary.

Figure 21: Summary shows the summary amounts of the cost elements. Multiplier is calculated by dividing the indirect cost, risk and profit against the direct cost to use it for every project items.

Item No	Description	Unit	Total Qty.	UNIT Direct Cost	Total Direct Cost	Multiplier %	Unit Price	Total
A	Excavation in ordinary soil	m³	**600**	20	12,000		**28**	16,768
B	Backfill with compacted sand	m³	**200**	35	7,000		**49**	9,782
C	Supply and cast plain concrete with average compressive strength 200 kg/cm2 at 28 days, with cement ratio of 250 kg/m3.	m³	**500**	885	442,500		**1,237**	618,335
D	Reinforced concrete Fcu=250 kg/cm2 for according to specifications..	m³	**800**	2,340	1,872,000	1.40	**3,270**	2,615,872
E	Solid cement brick walls 25cm thick	m³	**300**	515	154,514		**720**	215,913
F	Solid cement brick walls 12cm thick	m²	**4000**	63	250,547		**88**	350,106
G	Internal walls plaster	m²	**6000**	23	140,555		**33**	196,407
H	ceramic tiles.	m²	**3500**	124	433,355		**173**	605,556
TOTAL					**3,312,471.205**			**4,628,739.001**

Figure 22: Summary CBS.

Figure 22: Summary CBS shows the all of the project items with its direct cost and by using the multiplier, getting the unit price and total project price.

Cost Coding		
Category	Code	Description
Labor	L-1001	Civil General Supervisors
Labor	L-1002	Formwork labor
Labor	L-1003	Steel fixers labor
Labor	L-1004	Concrete labor
Labor	L-1005	Mason labor
Labor	L-1006	Insulation labor
Labor	L-1007	Morter Technician
Labor	L-1008	Lath&Plaster
Labor	L-1009	Tile labor
Labor	L-1010	Painting labor
Labor	L-1011	Electromechanical General Supervisors
Labor	L-1012	Plumbing/Piping labor
Labor	L-1014	Electrical labor
Labor	L-1015	Riggers
Labor	L-1016	Fitter
Labor	L-1017	Scaffolding Crew
Labor	L-1018	Chiseler
Labor	L-1019	Service Labor
Labor	L-1020	Miscellaneous Labor
Material	M-2001	Concrete Reinforcement Rebar
Material	M-2002	Concrete Formwork
Material	M-2003	Cement
Material	M-2004	Ready Mix Concrete
Material	M-2005	Brick Masonary unit
Material	M-2006	Waterproofing
Material	M-2007	Lath and Plaster
Material	M-2008	Painting
Material	M-2009	Ceramic Tile
Material	M-2010	HVAC Pipes & Fitting
Material	M-2011	Low Voltage Cable
Material	M-2012	Small Supplies
Material	M-2013	Small tools
Material	M-2014	Sand
Material	M-2015	Water
S/C	SC-3001	Excavation and Backfilling
S/C	SC-3002	Concrete Formwork
S/C	SC-3003	Concrete Reiforcement
S/C	SC-3004	Concrete
S/C	SC-3005	Masonry
S/C	SC-3006	Thermal and Moisture Protection
S/C	SC-3007	Lath, Plaster
S/C	SC-3008	Gypsum Board / GRC Works
S/C	SC-3009	Ceramic Tile
S/C	SC-3010	Painting
S/C	SC-3011	Exterior Façade (Marble-Granite-Stone)
S/C	SC-3012	Wooden Door & Window
S/C	SC-3013	Metal Door & Window
EQ	EQ-4001	Loaders
EQ	EQ-4002	Generators
EQ	EQ-4003	Forklift
EQ	EQ-4004	Viperator
EQ	EQ-4005	Helcopter
Indirect	I-5001	Salaries
Indirect	I-5002	Site Offices
Indirect	I-5003	Safety Expenses
Indirect	I-5004	Security Expenses
Indirect	I-5005	Warehouse
Financial	F-6001	Contract stamps
Financial	F-6002	Social insurance
Financial	F-6003	Bonds Expenses
Risk	R-7001	Risk Reserve

Figure 23: Coding system.

Figure 23: The coding System can be different from firm to another. The concept of a coding system is to define any cost item by a unique code to help collect cost data together.

									Labor ManHour			BAC		
Item No	Description	Unit	Total Qty.	UNIT Direct Cost	Total Direct Cost	Multiplier %	Unit Price	Total	PR=Unit/ Day	Total Manho	Rate/Hr	Cost	Cost Code	Description
	EARTHWORKS					1.40								
A	Excavation in ordinary soil	m³	600	20	12,000	1.40	28	16,800						
	Subcontractor			20.0	12,000									
	Excavation Subcontractor			20.0	12,000							12,000	SC-3001	Excavation and Backfilling
B	Backfill with compacted sand	m³	200	35	7,000	1.40	49	9,800						
	Subcontractor			35.0	7,000									
	Backfilling Subcontractor			35.0	7,000							7,000	SC-3001	Excavation and Backfilling
	CONCRETE													
C	Supply and cast plain concrete with average compressive strength 200 kg/cm2 at 28 days, with cement ratio of 250 kg/m3.	m³	500	885	442,500	1.40	1,239	619,500						
	Subcontractor			150.0	75,000									
	PC Subcontractor			150.0	75,000							75,000	SC-3004	Concrete
	Material			735.0	367,500									
	Plain Concrete			735.0	367,500							367,500	M-2004	Ready Mix Concrete
D	Reinforced concrete Fcu=250 kg/cm2 for foundations according to specifications..	m³	800	2,340	1,872,000	1.40	3,276	2,620,800						
	Subcontractor			450.0	360,000									
	RC Subcontractor			450.0	360,000							360,000	SC-3004	Concrete
	Material			1,890.0	1,512,000									
	Reinforcement Concrete			840.0	672,000							672,000	M-2004	Ready Mix Concrete
	Reinforcement Rebar			1,050.0	840,000							840,000	M-2001	Concrete Reinforcement Rebar
	MASONRY													
E	Solid cement brick walls 25cm thick	m³	300	515	154,514	1.40	721	216,320						
	Labor			140.0	42,000				2.50	960	44			
	Mason Technician		36%		15,120						16	15,120	L-1005	Mason labor
	Mason Assistant		25%		10,560						11	10,560	L-1005	Mason labor
	Morter Technician		23%		9,600						10	9,600	L-1007	Morter Technician
	Unskilled labor		16%		6,720						7	6,720	L-1020	Miscellaneous Labor
	Material			375.0	112,514									
	Cement Bricks			288.5	86,538							86,538	M-2005	Brick Masonary unit
	Cement			67.8	20,346							20,346	M-2003	Cement
	Sand			17.6	5,275							5,275	M-2014	Sand
	Water			1.2	355							355	M-2015	Water
F	Solid cement brick walls 12cm thick	m²	4000	63	250,547	1.40	88	350,766						
	Labor			17.5	70,000				20.0	1,600	44			
	Mason Technician		36%		25,200						16	25,200	L-1005	Mason labor
	Mason Assistant		25%		17,600						11	17,600	L-1005	Mason labor
	Morter Technician		23%		16,000						10	16,000	L-1007	Morter Technician
	Unskilled labor		16%		11,200						7	11,200	L-1020	Miscellaneous Labor
	Material			45.1	180,547									
	Cement Bricks			37.5	150,000							150,000	M-2005	Brick Masonary unit
	Cement			6.0	23,926							23,926	M-2003	Cement
	Sand			1.6	6,203							6,203	M-2014	Sand
	Water			0.1	418							418	M-2015	Water
	PLASTER													
G	Internal walls plaster	m²	6000	23	140,555	1.40	33	196,777						
	Labor			12.7	76,216				37.0	1,297	58.75			
	Plasterer		30%		23,027						17.75	23,027	L-1008	Lath&Plaster
	2 Morter Technician		34%		25,946						20	25,946	L-1007	Morter Technician
	3 Unskilled labor		36%		27,243						21	27,243	L-1020	Miscellaneous Labor
	Material			10.7	64,339									
	Cement			8.7	52,448							52,448	M-2003	Cement
	Sand			1.8	11,025							11,025	M-2014	Sand
	Water			0.1	866							866	M-2015	Water
	TILES													
H	ceramic tiles.	m²	3500	124	433,355	1.40	173	606,697						
	Labor			17.7	61,833				15.0	1,867	33			
	Ceramic Technician		58%		35,700						19	35,700	L-1009	Tile labor
	2 Unskilled labor		42%		26,133						14	26,133	L-1020	Miscellaneous Labor
	Material			106.1	371,522									
	Ceramic			94.5	330,750							330,750	M-2009	Ceramic Tile
	Cement			5.7	19,845							19,845	M-2003	Cement
	Sand			5.9	20,580							20,580	M-2014	Sand
	Water			0.1	347							347	M-2015	Water
	TOTAL				3,312,471.205			4,637,459.687				3,312,471		

Figure 24: BAC-Direct cost.

Figure 24: BAC-Direct Cost shows the budget at completion for the direct cost and the allocation of the cost by using cost codes to generate the original budget of the project.

	Equipment	Hour Rate	Months	Hrs	TOTAL	Cost	Cost Code	Des
1	Loader	180.0	6.0	1248.0	224,640	224,640	EQ-4001	Loaders
2	Forklift	75.0	2.0	416.0	31,200	31,200	EQ-4003	Forklift
3	Generator	150.0	6.0	1248.0	187,200	187,200	EQ-4002	Generators
	Total				**443,040**	443,040		

Figure 25: BAC-Equipment.

Figure 25: BAC-Equipment shows the budget at completion for the equipment cost and the allocation of the cost by using cost codes to generate the original budget of the project.

	Staff	Rate	Months	Hrs	TOTAL		Cost	Cost Code	Des
1	Project Manager	12000.0	6.0	1248.0	72,000		72,000	I-5001	Salaries
2	Site Engineer	5500.0	6.0	1248.0	33,000		33,000	I-5001	Salaries
3	Technical Office Engineer	5000.0	6.0	1248.0	30,000		30,000	I-5001	Salaries
4	Surveyor	4500.0	5.0	1040.0	22,500		22,500	I-5001	Salaries
5	HSE Engineer	4000.0	6.0	1248.0	24,000		24,000	I-5001	Salaries
6	Store Keeper	3500.0	6.0	1248.0	21,000		21,000	I-5001	Salaries
	Total	**34500**			**202,500**		202,500		
	Other Indirect Cost						**Cost**	**Cost Code**	**Des**
1	Site offices and other office supplies				35,000		35,000	I-5002	Site Offices
2	Safety Expenses				10,000		10,000	I-5003	Safety Expenses
3	Security Expenses	1500	6		9,000		9,000	I-5004	Security Expenses
	Total				**54,000**		54,000		

Figure 26: BAC-Indirect cost.

Figure 26: BAC-Indirect Cost shows the budget at completion for the indirect cost and the allocation of the cost by using cost codes to generate the original budget of the project.

	Financial and Markup			Total Cost Direct + Indirect	Amount		Cost	Cost Code	Desp.
4	Bonds Costs	0.75%	of total price	4,012,011	30,317		30,317	F-6003	Bonds Expenses
5	Insurance	2.00%	of total price	4,012,011	81,878		81,878	F-6002	Social insurance
6	Risk and Contingency	1.00%	of total price	4,124,206	41,659		41,659	R-7001	Risk Reserve
7	Profit	10.00%	of total price	4,165,865	462,874		462,874		
	Total				**616,728**		616,728		

Figure 27: BAC-Financial & Markup.

Figure 27: BAC-Financial & Markup shows the budget at completion for the financial and markup cost and the allocation of the cost by using cost codes to generate the original budget of the project.

Date	Year	Month	Month No.	Entry No.	Entry Description	Posting Type	Cost Code	Description	PO/Invoice No.	Supplier/Subcontractor Name	Currency	Equivalent EGP Amount	Unit Rate	Unit	No.	QTY	Comments
Labor																	
1-Jan-2019	2019	Jan	Month 1	1	Mason Technician	Wages	L-1005	Mason labor			EGP	5,760	15	Hr	2	192	
1-Jan-2019	2019	Jan	Month 1	2	Mason Assistant	Wages	L-1005	Mason labor			EGP	3,840	10	Hr	2	192	
1-Jan-2019	2019	Jan	Month 1	3	Morter Technician	Wages	L-1007	Morter Technician			EGP	7,680	10	Hr	4	192	2 in Masonary (25cm) & 1 in Plaster & 1 In Tiles
1-Jan-2019	2019	Jan	Month 1	4	Plasterer	Wages	L-1008	Lath&Plaster			EGP	3,456	18	Hr	1	192	
1-Jan-2019	2019	Jan	Month 1	5	Ceramic Technician	Wages	L-1009	Tile labor			EGP	3,456	18	Hr	1	192	
1-Jan-2019	2019	Jan	Month 1	6	Unskilled labor	Wages	L-1020	Miscellaneous Labor			EGP	9,408	7	Hr	7	192	2 in Masonary (25cm) & 3 in Plaster & 2 In Tiles
Material																	
1-Jan-2019	2019	Jan	Month 1	7	Concrete Reinf. Rebar	Material	M-2001	Concrete Reinforcement Rebar	PO-1	EZZ Steel	EGP	19,600	9,800	ton		2	
1-Jan-2019	2019	Jan	Month 1	8	Reinforcement Concrete	Material	M-2004	Ready Mix Concrete	PO-2	Lafarge	EGP	15,800	790	m3		20	
1-Jan-2019	2019	Jan	Month 1	9	Cement Bricks	Material	M-2005	Brick Masonary unit	PO-6	Toplat	EGP	178,750	650	Thousand		275	All in wall 25 cm
1-Jan-2019	2019	Jan	Month 1	10	Cement	Material	M-2003	Cement	PO-4	Lafarge	EGP	4,500	900	ton		5	
1-Jan-2019	2019	Jan	Month 1	11	Sand	Material	M-2014	Sand	PO-3	Misr	EGP	1,625	65	m3		25	
1-Jan-2019	2019	Jan	Month 1	12	Water	Material	M-2015	Water	PO-5	Misr	EGP	1,500	30	m3		50	
1-Jan-2019	2019	Jan	Month 1	13	Ceramic	Material	M-2009	Ceramic Tile	PO-7	Celopatra	EGP	180	90	m2		2	
1-Jan-2019	2019	Jan	Month 1	14	Safety Shoes	Indirect	I-5003	Safety Expenses	PO-8	WAQ	EGP	4,600	200	Ea		23	SiteManpower
1-Jan-2019	2019	Jan	Month 1	15	Safety Helmet	Indirect	I-5003	Safety Expenses	PO-8	WAQ	EGP	3,450	150	Ea		23	SiteManpower
1-Jan-2019	2019	Jan	Month 1	16	Safety Vest	Indirect	I-5003	Safety Expenses	PO-8	WAQ	EGP	345	15	Ea		23	SiteManpower
1-Jan-2019	2019	Jan	Month 1	17	Safety Glasses	Indirect	I-5003	Safety Expenses	PO-8	WAQ	EGP	230	10	Ea		23	SiteManpower
Subcontractor																	
1-Jan-2019	2019	Jan	Month 1	18	Excavation Subcontractor	Subcontractor	SC-3001	Excavation and Backfilling	IPC-1	Misr	EGP	1,000					
1-Jan-2019	2019	Jan	Month 1	19	Backfilling Subcontractor	Subcontractor	SC-3001	Excavation and Backfilling	IPC-2	Misr	EGP	100					
1-Jan-2019	2019	Jan	Month 1	20	PC Subcontractor	Subcontractor	SC-3004	Concrete	IPC-1	2M	EGP	60,000					
1-Jan-2019	2019	Jan	Month 1	21	RC Subcontractor	Subcontractor	SC-3004	Concrete	IPC-2	2M	EGP	25,000					
1-Jan-2019	2019	Jan	Month 1	22	Rental-Forklift	Subcontractor	EQ-4003	Forklift	IPC-1	Misr	EGP	14,560			1		
1-Jan-2019	2019	Jan	Month 1	23	Rental-Loader	Subcontractor	EQ-4001	Loaders	IPC-1	Misr	EGP	36,400			1		
1-Jan-2019	2019	Jan	Month 1	24	Rental-Generator	Subcontractor	EQ-4002	Generators	IPC-1	Misr	EGP	31,200			1		
Other Costs																	
1-Jan-2019	2019	Jan	Month 1	25	Staff Salaries	Indirect	I-5001	Salaries			EGP	34,500		Hr		7,280	
1-Jan-2019	2019	Jan	Month 1	26	Security Expenses	Indirect	I-5004	Security Expenses	IPC-1	Misr	EGP	1,500					
1-Jan-2019	2019	Jan	Month 1	27	Depreciation-Site Offices	Indirect	I-5002	Site Offices	PO-1	EECS	EGP	972					
1-Jan-2019	2019	Jan	Month 1	28	Insurance	Indirect	F-6002	Social insurance				13,650					
1-Jan-2019	2019	Jan	Month 1	29	Bonds Costs	Indirect	F-6003	Bonds Expenses				5,000					
TOTAL												488,062					

Figure 28: Actual cost "AC" transaction.

Figure 28: Actual Cost "AC" Transaction shows the actual cost that contains labor cost, material cost, equipment cost, subcontractor cost and other costs. Transaction report contains all detailed and required data for monitoring and control reports.

		Construction Labor		Days	26					
				Hours	8	1.00				
		Workers Plan		Overtime	2	1.35				
Filter	CR Code	Description	Hour Rate	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	TOTAL
Plan No.	L-1005	Mason labor	15.0	2	3	4	3	2		
Plan Cost	L-1005	Mason labor		8,346	12,519	16,692	12,519	8,346		58,422
Plan No.	L-1007	Morter Technician	8.0	3	5	7	5	2	1	
Plan Cost	L-1007	Morter Technician		6,677	11,128	15,579	11,128	4,451	2,226	51,189
Plan No.	L-1008	Lath&Plaster	10.0	1	2	2	2	1	1	
Plan Cost	L-1008	Lath&Plaster		2,782	5,564	5,564	5,564	2,782	2,782	25,038
Plan No.	L-1009	Tile labor	7.0	2	4	4	4	2	2	
Plan Cost	L-1009	Tile labor		3,895	7,790	7,790	7,790	3,895	3,895	35,053
Plan No.	L-1020	Miscellaneous Labor	5.0	8	10	12	10	8	4	
Plan Cost	L-1020	Miscellaneous Labor		11,128	13,910	16,692	13,910	11,128	5,564	72,332
		Total Wages		32,828	50,911	62,317	50,911	30,602	14,466	242,034

Figure 29: EAC-Labor.

Figure 29: EAC-Labor shows an estimate at completion for the labor cost and the allocation of the cost by using cost codes to calculate the forecast of the project.

		Construction Equipment		Days	26					
				Hours	8	1.00				
		Equipment Plan								
Filter	CR Code	Description	Hour Rate	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	TOTAL
Plan No.	EQ-4001	Loaders	175.0	1	1	1	1	1	1	
Plan Cost	EQ-4001	Loaders		36,400	36,400	36,400	36,400	36,400	36,400	218,400
Plan No.	EQ-4002	Generators	150.0	1	1	1	1	1	1	
Plan Cost	EQ-4002	Generators		31,200	31,200	31,200	31,200	31,200	31,200	187,200
Plan No.	EQ-4003	Forklift	70.0	1	1	1				
Plan Cost	EQ-4003	Forklift		14,560	14,560	14,560				43,680
		Total Wages		82,160	82,160	82,160	67,600	67,600	67,600	449,280

Figure 30: EAC- Equipment.

Figure 30: EAC- Equipment shows an estimate at completion for the equipment cost and the allocation of the cost by using cost codes to calculate the forecast of the project.

Purchase Orders Summary							
Date	PO	Supplier Name	Material	Currency	Total Amount	Cost Code	Description
	PO-1	EZZ Steel	Concrete Reinf. Rebar	EGP	845,000	M-2001	Concrete Reinforcement Rebar
	PO-2	Lafarge	Reinforcement Concrete	EGP	1,040,000	M-2004	Ready Mix Concrete
	PO-3	Misr	Sand	EGP	45,000	M-2014	Sand
	PO-4	Lafarge	Cement	EGP	120,000	M-2003	Cement
	PO-5	Misr	Water	EGP	1,800	M-2015	Water
	PO-6	Toplat	Cement Bricks	EGP	225,000	M-2005	Brick Masonary unit
	PO-7	Celopatra	Ceramic	EGP	330,500	M-2009	Ceramic Tile
	PO-8	WAQ	Safety Shoes	EGP	10,000	I-5003	Safety Expenses
		Total			2,617,300		

Figure 31: EAC- Material.

Figure 31: EAC- Material shows an estimate at completion for the material cost and the allocation of the cost by using cost codes to calculate the forecast of the project.

Subcontractors Contracts Summary

Date	Subcontractor Name	Work Type	Currency	Unit	QTY	Rate	Total Amount	Cost Code	Description
	Misr	Excavation	EGP	m3	600	22	13,200	SC-3001	Excavation and Backfilling
	Misr	Backfilling	EGP	m3	200	36	7,200	SC-3001	Excavation and Backfilling
	2M	Plain Concrete	EGP	m3	500	150	75,000	SC-3004	Concrete
	2M	Reinforcement Concrete	EGP	m3	800	430	344,000	SC-3004	Concrete
	Total						439,400		

Figure 32: EAC- Subcontractor.

Figure 32: EAC- Subcontractor shows estimate at completion for the subcontractor cost and the allocation of the cost by using cost codes to calculate the forecast of the project.

Staff Plan

Filter	CR Code	Description	Monthly Rate	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6	TOTAL
Plan No.	I-5001	Project Manager	12,000	1	1	1	1	1	1	
Plan Cost	I-5001	Project Manager		12,000	12,000	12,000	12,000	12,000	12,000	72,000
Plan No.	I-5001	Site Engineer	5,500	1	1	1	1	1	1	
Plan Cost	I-5001	Site Engineer		5,500	5,500	5,500	5,500	5,500	5,500	33,000
Plan No.	I-5001	Technical Office Eng	5,000	1	1	1	1	1	1	
Plan Cost	I-5001	Technical Office Eng		5,000	5,000	5,000	5,000	5,000	5,000	30,000
Plan No.	I-5001	Surveyor	4,500	1	1	1	1	1		
Plan Cost	I-5001	Surveyor		4,500	4,500	4,500	4,500	4,500		22,500
Plan No.	I-5001	HSE Engineer	4,000	1	1	1	1	1	1	
Plan Cost	I-5001	HSE Engineer		4,000	4,000	4,000	4,000	4,000	4,000	24,000
Plan No.	I-5001	Store Keeper	3,500	1	1	1	1	1	1	
Plan Cost	I-5001	Store Keeper		3,500	3,500	3,500	3,500	3,500	3,500	21,000
	Total Wages			34,500	34,500	34,500	34,500	34,500	30,000	202,500

Figure 33: EAC- Staff.

Figure 33: EAC- Staff shows an estimate at completion for the staff cost and the allocation of the cost by using cost codes to calculate the forecast of the project.

Cost Report

Code	Description	BAC EGP	AC EGP	ETC EGP	EAC EGP	VAC EGP
Direct						
Labor						
L-1005	Mason labor	68,480	9,600	48,822	58,422	10,058
L-1007	Morter Technician	51,546	7,680	43,509	51,189	357
L-1008	Lath&Plaster	23,027	3,456	21,582	25,038	-2,011
L-1009	Tile labor	35,700	3,456	31,597	35,053	647
L-1020	Miscellaneous Labor	71,297	9,408	62,924	72,332	-1,035
Total Labor		**250,050**	**33,600**	**208,434**	**242,034**	**8,016**
Material						
M-2001	Concrete Reinforcement Rebar	840,000	19,600	825,400	845,000	-5,000
M-2003	Cement	116,565	4,500	115,500	120,000	-3,435
M-2004	Ready Mix Concrete	1,039,500	15,800	1,024,200	1,040,000	-500
M-2005	Brick Masonary unit	236,538	178,750	46,250	225,000	11,538
M-2009	Ceramic Tile	330,750	180	330,320	330,500	250
M-2014	Sand	43,083	1,625	43,375	45,000	-1,917
M-2015	Water	1,986	1,500	300	1,800	186
Total Material		**2,608,422**	**221,955**	**2,385,345**	**2,607,300**	**1,122**
SC						
SC-3001	Excavation and Backfilling	19,000	1,100	19,300	20,400	-1,400
SC-3004	Concrete	435,000	85,000	334,000	419,000	16,000
Total SC		**454,000**	**86,100**	**353,300**	**439,400**	**14,600**
Total Direct		**3,312,471**	**341,655**	**2,947,079**	**3,288,734**	**23,737**
Indirect						
EQ						
EQ-4001	Loaders	224,640	36,400	182,000	218,400	6,240
EQ-4002	Generators	187,200	31,200	156,000	187,200	
EQ-4003	Forklift	31,200	14,560	29,120	43,680	-12,480
Total EQ		**443,040**	**82,160**	**367,120**	**449,280**	**-6,240**
Other Indirect						
I-5001	Salaries	202,500	34,500	168,000	202,500	
I-5002	Site Offices	35,000	972	34,028	35,000	
I-5003	Safety Expenses	10,000	8,625	1,375	10,000	
I-5004	Security Expenses	9,000	1,500	7,500	9,000	
Total Other Indirect		**256,500**	**45,597**	**210,903**	**256,500**	
Finance						
F-6002	Insurance	81,878	13,650	68,228	81,878	
F-6003	Bonds Expenses	30,317	5,000	25,317	30,317	
Total Finance		**112,195**	**18,650**	**93,545**	**112,195**	
Risk						
R-7001	Risk Reserve	41,659		41,659	41,659	
Total Risk		**41,659**		**41,659**	**41,659**	
Grand Total		**4,165,865**	**488,062**	**3,660,306**	**4,148,368**	**17,497**
Gross Profit		**462,874**			**480,371**	
Gross Profit %		**10.00%**			**10.38%**	
Contract Value		**4,628,739**	**488,062**	**3,660,306**	**4,628,739**	**17,497**

Figure 34: Cost Report.

Figure 34: Cost Report is the main report to calculate budget, actual, estimate, forecast, variance, and project profit.

Worker Plan vs Actual								
Filter	Code	Description	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
		Direct Workers						
Plan No.	L-1005	Mason labor	2	3	4	3	2	
Act. No.	L-1005	Mason labor	4					
Plan Cost	L-1005	Mason labor	8,346	12,519	16,692	12,519	8,346	
Act. Cost	L-1005	Mason labor	9,600					
Act. Hr.	L-1005	Mason labor	384					
Hr. Rate	L-1005	Mason labor	25					
Plan No.	L-1007	Morter Technician	3	5	7	5	2	1
Act. No.	L-1007	Morter Technician	4					
Plan Cost	L-1007	Morter Technician	6,677	11,128	15,579	11,128	4,451	2,226
Act. Cost	L-1007	Morter Technician	7,680					
Act. Hr.	L-1007	Morter Technician	192					
Hr. Rate	L-1007	Morter Technician	40					
Plan No.	L-1008	Lath&Plaster	1	2	2	2	1	1
Act. No.	L-1008	Lath&Plaster	1					
Plan Cost	L-1008	Lath&Plaster	2,782	5,564	5,564	5,564	2,782	2,782
Act. Cost	L-1008	Lath&Plaster	3,456					
Act. Hr.	L-1008	Lath&Plaster	192					
Hr. Rate	L-1008	Lath&Plaster	18					
Plan No.	L-1009	Tile labor	2	4	4	4	2	2
Act. No.	L-1009	Tile labor	1					
Plan Cost	L-1009	Tile labor	3,895	7,790	7,790	7,790	3,895	3,895
Act. Cost	L-1009	Tile labor	3,456					
Act. Hr.	L-1009	Tile labor	192					
Hr. Rate	L-1009	Tile labor	18					
Plan No.	L-1020	Miscellaneous Labor	8	10	12	10	8	4
Act. No.	L-1020	Miscellaneous Labor	7					
Plan Cost	L-1020	Miscellaneous Labor	11,128	13,910	16,692	13,910	11,128	5,564
Act. Cost	L-1020	Miscellaneous Labor	9,408					
Act. Hr.	L-1020	Miscellaneous Labor	192					
Hr. Rate	L-1020	Miscellaneous Labor	49					
		TOTAL PLAN No.	16	24	29	24	15	8
		TOTAL ACTUAL No.	17					
		VARIANCE	-1					
		TOTAL COST	33,600					
		TOTAL HOURS	1,152					
		Avg. Hour Rate	29					

Figure 35: Worker Plan vs Actual.

Figure 35: Worker Plan vs Actual shows the detailed labor monitoring and control for numbers, hours and wages.

		Productivity Plan vs Actual	Cost / QTY						
Filter	Code	Description	Crew	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
E	m3	Solid cement brick walls 25cm thick							
Act. QTY.		Solid cement brick walls 25cm thick		116					
Act. Cost	L-1007	Mason Technician	1	5,760					
Act. Cost	L-1007	Mason Assistant	1	3,840					
Act. Cost	L-1007	Morter Technician	1	3,840					
Act. Cost	L-1020	Unskilled labor	1	2,688					
		PLAN PRODUCTIVITY		140	140	140	140	140	140
		ACTUAL PRODUCTIVITY		139					
		VARIANCE		1					

Figure 36: Productivity Plan vs Actual.

Figure 36: Productivity Plan vs Actual shows the comparison between the productivity of the actual labor crew to the plan. Productivity is "the ratio of the total output produced to the total inputs used".

$$Productivity = Output / Input \quad (3)$$

		Production Rate Plan vs Actual	Hrs / QTY						
Filter	Code	Description	Crew	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
E	m3	Solid cement brick walls 25cm thick							
Act. QTY.		Solid cement brick walls 25cm thick		116					
Act. Cost	L-1007	Mason Technician	1	192					
Act. Cost	L-1007	Mason Assistant	1	192					
Act. Cost	L-1007	Morter Technician	1	96					
Act. Cost	L-1020	Unskilled labor	1	55					
		PLAN PRODUCTIVITY		3.20	3.20	3.20	3.20	3.20	3.20
		ACTUAL PRODUCTIVITY		4.60					
		VARIANCE		-1.40					

Figure 37: Production Rate "PR" Plan vs Actual.

Figure 37: Production Rate Plan vs Actual shows the comparison between the production rate of the actual labor crew to the plan. Production rate is the quantity of total production produced by specific labor crews in a unit of time.

$$Production\ Rate = Output / Time \quad (4)$$

Staff Plan vs Actual								
Filter	**Code**	**Description**	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Staff								
Plan Cost	I-5001	Staff Salaries	34,500	34,500	34,500	34,500	34,500	30,000
Act. Cost	**I-5001**	**Staff Salaries**	**34,500**					
Variance	**I-5001**	**Staff Salaries**						

Figure 38: Staff Plan vs Actual.

Figure 38: Staff Plan vs Actual shows the comparison between the salaries of the actual staff members to the plan.

PO	Supplier Name	Currency	Unit	QTY	Waste	Total QTY	Rate	Total Amount	Material	Unit	Quantity Surveying	Total Amount	Variance
PO-1	EZZ Steel	EGP	ton	80	5%	85	10000	845,000	Concrete Reinf. Rebar	ton	79	829,500	15,500
PO-2	Lafarge	EGP	m3	1238	5%	1300	800	1,040,000	Reinforcement Concrete	m3	1232	1,034,880	5,120
PO-3	Misr	EGP	m3	612	5%	643	70	45,000	Sand	m3	618	45,423	-423
PO-4	Lafarge	EGP	ton	127	5%	133	900	120,000	Cement	ton	126	119,070	930
PO-5	Misr	EGP	m3	55	10%	60	30	1,800	Water	m3	55	1,815	-15
PO-6	Toplat	EGP	1000	330	5%	346	650	225,000	Cement Bricks	1000	330	225,225	-225
PO-7	Celopatra	EGP	m2	3497	5%	3672	90	330,500	Ceramic	m2	3497	330,500	0
	Total							**2,607,300**				**2,586,413**	**20,887**

Figure 39: Material Quantity Surveying vs Purchase Orders.

Figure 39: Material Quantity Surveying vs Purchase Orders shows the comparison between the purchase order quantity and the calculated quantity.

Material	Quantity Surveying (Technical Office)	Actual Quantity (Site)	Planned Waste	Actual Waste	Variance
Concrete Reinf. Rebar	79	81	5.0%	3.0%	204
Reinforcement Concrete	1232	1288	5.0%	4.5%	4
Sand	618	652	5.0%	7.0%	-1
Cement	126	132	5.0%	4.8%	2
Water	55	60	10.0%	20.0%	-3
Cement Bricks	330	346	5.0%	4.9%	1
Ceramic	3497	3637	5.0%	4.0%	1
Total					**206**

Figure 40: Material Wastage Plan vs Actual.

Figure 40: Material Wastage Plan vs Actual shows the comparison between the actually used quantity and the calculated quantity. This enables monitoring and control of the waste material used.

Work Type	Unit	Quantity Surveying	Subcontractor Name	Currency	Unit	QTY	Rate	Total Amount	Variance with SC. Contract
Excavation	m3	600	Misr	EGP	m3	600	22	13,200	
Backfilling	m3	200	Misr	EGP	m3	200	36	7,200	
Plain Concrete	m3	500	2M	EGP	m3	500	150	75,000	
Reinforcement Concrete	m3	800	2M	EGP	m3	800	430	344,000	
			Total					**439,400**	

Figure 41: Subcontractor "S.C." Quantity Surveying vs Contracts.

Figure 41: Subcontractor "S.C." Quantity Surveying vs Contracts shows the comparison between the contract of subcontractor quantity and the calculated quantity.

Equipment Plan vs Actual								
Filter	Code	Description	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Equipment								
Plan No.	EQ-4001	Loaders	1	1	1	1	1	1
Act. No.	EQ-4001	Loaders	1					
Plan Cost	EQ-4001	Loaders	36,400	36,400	36,400	36,400	36,400	36,400
Act. Cost	EQ-4001	Loaders	36,400					
Variance	EQ-4001	Loaders						
Plan No.	EQ-4002	Generators	1	1	1	1	1	1
Act. No.	EQ-4002	Generators	1					
Plan Cost	EQ-4002	Generators	31,200	31,200	31,200	31,200	31,200	31,200
Act. Cost	EQ-4002	Generators	31,200					
Variance	EQ-4002	Generators						
Plan No.	EQ-4003	Forklift	1	1	1			
Act. No.	EQ-4003	Forklift	1					
Plan Cost	EQ-4003	Forklift	14,560	14,560	14,560			
Act. Cost	EQ-4003	Forklift	14,560					
Variance	EQ-4003	Forklift						

Figure 42: Equipment Plan vs Actual.

Figure 42: Equipment Plan vs Actual shows the detailed equipment monitoring and control for numbers, and cost amount.

7 Results and Discussion

The model helped in monitoring and controlling the project from its start. The model combined all the construction cost data in one resource creating not only a cost monitoring and control system but also a whole cost management system from the cost estimation process to the cost control process. The model showed the project budget, the project actual cost, the project forecast, and the project profit in one report. The model provided all variances and tracking reports required to monitor and control every project cost element and resource such as labor, material, subcontractor, equipment, staff, and

more on monthly basis and as a total. The model helped in the management of the project cost remotely effectively and easily.

8 CONCLUSION:

A model is provided in this study to monitor and control the construction cost in the construction firms using a tool (Microsoft Excel spreadsheet) showing the inputs requires as cost estimation for different project resources, processing required to make cost baseline, actual cost, and coding system, and reports outputs helping the monitoring and the control of the construction project cost. The inputs include: Bill of Quantity "BOQ", Cost Break down "CBS", Resources Cost, Labor Production Rate, Consumption Rate, CBS-Equipment, CBS-Other Indirect Cost, CBS-Financial & Markup, Summary, and Summary CBS. The Processing includes: Coding System contains Cost Coding used, Cost Baseline Budget at Completion "BAC" contains, BAC-Direct Cost, BAC-Equipment, BAC-Indirect Cost and BAC-Financial & Markup, Actual Cost "AC" contains AC-Transaction Report, and Estimate At Completion "EAC" contains EAC-Labor, EAC-Equipment, EAC-Material, EAC-Subcontractor, and EAC-Staff. The outputs include: Main General Report which is the Cost Report, Labor monitoring and control contains Worker Plan vs Actual, Productivity Plan vs Actual, Production Rate Plan vs Actual, Staff monitoring and control contains Staff Plan vs Actual, Material monitoring and control contain Material Quantity Surveying vs Purchase Orders and Wastage Plan vs Actual, Subcontractor monitoring and control contains S.C. Quantity Surveying vs Contracts, Equipment monitoring and control contains Equipment Plan vs Actual. The model was validated through a case study and it found that the model helped the managers to evaluate the performance of the project and control the resource consumption by its reports.

9 Disclosure Statement

No potential conflict of interest was reported by the authors.

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