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Estimation and Management of Construction Cost

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Abstract: *The cost management for construction enterprises is an important asset of the process of engineering cost control in construction. This article will give a slight insight of procedures of the construction cost management in the construction stage. Cost is of prime importance, at each stage of construction especially planning and design stages. Cost considerations are continually present, from inception to the end of life of the project, which includes- project budget, design cost, procurement cost, operation cost, maintenance cost, and ultimately demolition cost. It takes into account the detailed cost planning and cost control services to ensure construction projects are bid, documented and completed within a pre-agreed cost framework and in the most economical manner.The project is carried out to have a study about Cost Management in constructions and its implementation. In recent years project management software systems like MS PROJECT, PRIMAVERA, etc. have been improving continuously and recent versions have been proved to be more user friendly and helps a lot in planning and designing of the project accurately and efficiently.*

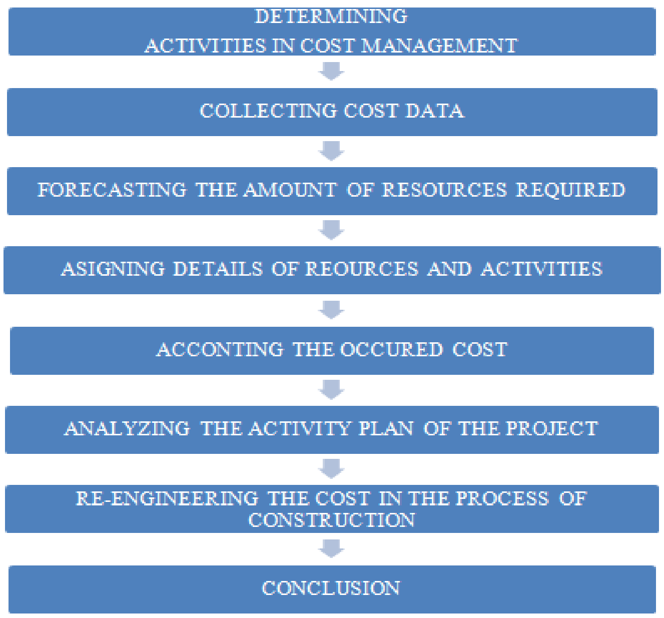
Keywords*: Cost Estimation, Cost Management, Cost Control, Project Life Cycle, Project Planning, Cost Overrun*

I. Introduction

A project is an endeavor to achieve a desired goal. The achievement of this goal requires careful planning and management. A project is divided into tasks, which can be thought of as mini-projects or temporary goals. These tasks, which collectively define the goal of the project, cannot be executed in any arbitrary order, instead their execution sequence is constrained by limits on, the duration and cost of the project, resource availability, construction methodology, and practical feasibility. Design and construction are treated as two independent and separate activities.

In order to demonstrate the practicality of the new computational and information models for management and scheduling of actual construction projects, they have been implemented in a new generation software system, called CONSCOM (Construction Scheduling, Cost Optimization, and Change Order Management).

II. Methodology



Project Planning And Management

To ensure that the project goals are met within the stipulated time and cost, effective project planning and management is needed. Planning ensures that the project manager gets the opportunity to analyze the work required and determine the appropriate strategies based on resource availability, construction methodology, constructability, cost, and time. The result of this analysis is documented in a plan. Project management is needed to maintain the plan so that it correctly reflects the current state of the project and make out the future strategy needed to achieve the project's goals. An important task in project management is to analyze andevaluate the plan. The owner has to verify the accuracy of the contractor's plan before it can be approved. Plans are also reviewed periodically to monitor progress and also when the contractor claims a change order. An objective way of analyzing such changes is essential to avoid any unfair advantage and the possibility of subsequent litigation.

Figure: *Project Planning and Management as a Concurrent and Collaborative Engineering Model*

III. Attributes of A Project

Projects can be characterized by several attributes. These attributes can be divided into two categories: static and dynamic. Static attributes are those that do not change during the execution of the project. These attributes are derived from the project specifications. Examples of static attributes include project goal, cost, duration, and number of tasks.

Dynamic attributes are those that change during the execution of the project. Examples of dynamic attributes include resources utilized, time elapsed, and number of tasks completed.

A project is completely defined by the project's specification. However, the static attributes defined in the specification do not provide the contractor or the owner with information needed for monitoring and controlling the progress of the project. For this reason, dynamic attributes are needed in project management.

Scheduling

The process of creating and maintaining a plan of work that documents the sequence and timetable of execution is called scheduling. As such, scheduling considers only the time attribute of the project and not the cost. However, time and cost are not independent of each other. This can lead to poor planning and management. The scheduling model should be general and flexible in order to capture the actual operation conditions on site.

Progress Monitoring

Progress monitoring is an essential part of any project control and management problem. In project management, progress monitoring essentially involves two tasks: (1) determining the current state of the project and (2) determining the deviation of the current state from the pre-planned state of the project at a given time. This information can then be used to plan and control the future progress in such a way that the project goals are satisfied. Progress monitoring requires accurate and consistently reliable inspections and analysis. This in turn requires schedules that accurately represent the state of the project at any given time.

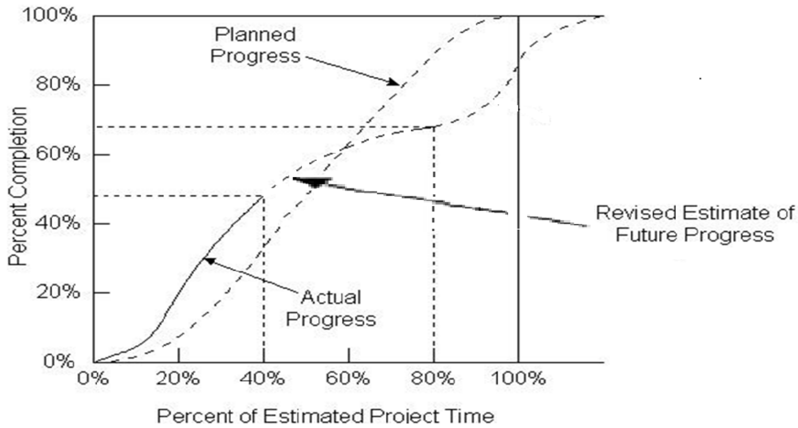


Figure: *Progress Graph*

Time And Cost Estimation

Time and cost estimates are the building blocks of project planning and management. Estimates are used to ascertain project feasibility and to develop and maintain detailed schedules and plans. In current industry practice, time and cost estimates are determined somewhat arbitrarily by schedulers based on their understanding of the conditions.As we all know that if a project is delayed the cost of the project would increase and also if the cost of work is increased for each task or small goals, which in turn would allow the heavy machines to be used or more labourers are to be put to work for a single task then the delays may be ignored. So Time and Cost has a strong and a very important relationship with each other.

IV. Cost Management

Project cost management ensures that the project is completed within budget and also that the budget is prepared accurately and economically according to the owner's requirements. As such, issues such as work crew and equipment sequencing, allocation, and distribution have to be considered. These issues should be considered together with the time and schedule of the project. Further, the project participants desire a plan that has the minimum cost, this allows us to incorporate cost optimization in our scheduling model to produce reliable minimum cost schedules.

Change Order Management

Change management ensures that change orders initiated in a project during the construction phase are handled fairly and reliably. This requires objective decision making capabilities derived from reliable information about the state of the project.

Cost Overrun

Some of the factors associated with the cost overrun in a project are:

- Inflation of prices
- Fluctuation of currency/exchange rate
- Unstable government policies
- Weak regulation and control
- Unpredictable weather Conditions
- Low skilled manpower
- Risk and uncertainty associated with projects
- Lack of proper training and experience of PM
- Inaccurate evaluation of projects time/duration
- Design changes
- Project fraud and corruption
- Discrepancies in contract documentation
- Conflict between project parties

V. Results And Discussion

Cost Estimation

Cost estimating is one of the most important steps in project management. A cost estimate establishes the base line of the project cost at different stages of development of the project. A cost estimate at a given stage of project development represents a prediction provided by the cost engineer or estimator on the basis of available data. According to the American Association of Cost Engineers, cost engineering is defined as that area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to the problem of cost estimation, cost control and profitability.

Formulae

$C_f = \quad C_t / P_t$ (1)

Where, total cost, C_f, C_t is the cost incurred to time t and p_t is the proportion of the activity completed at time t.

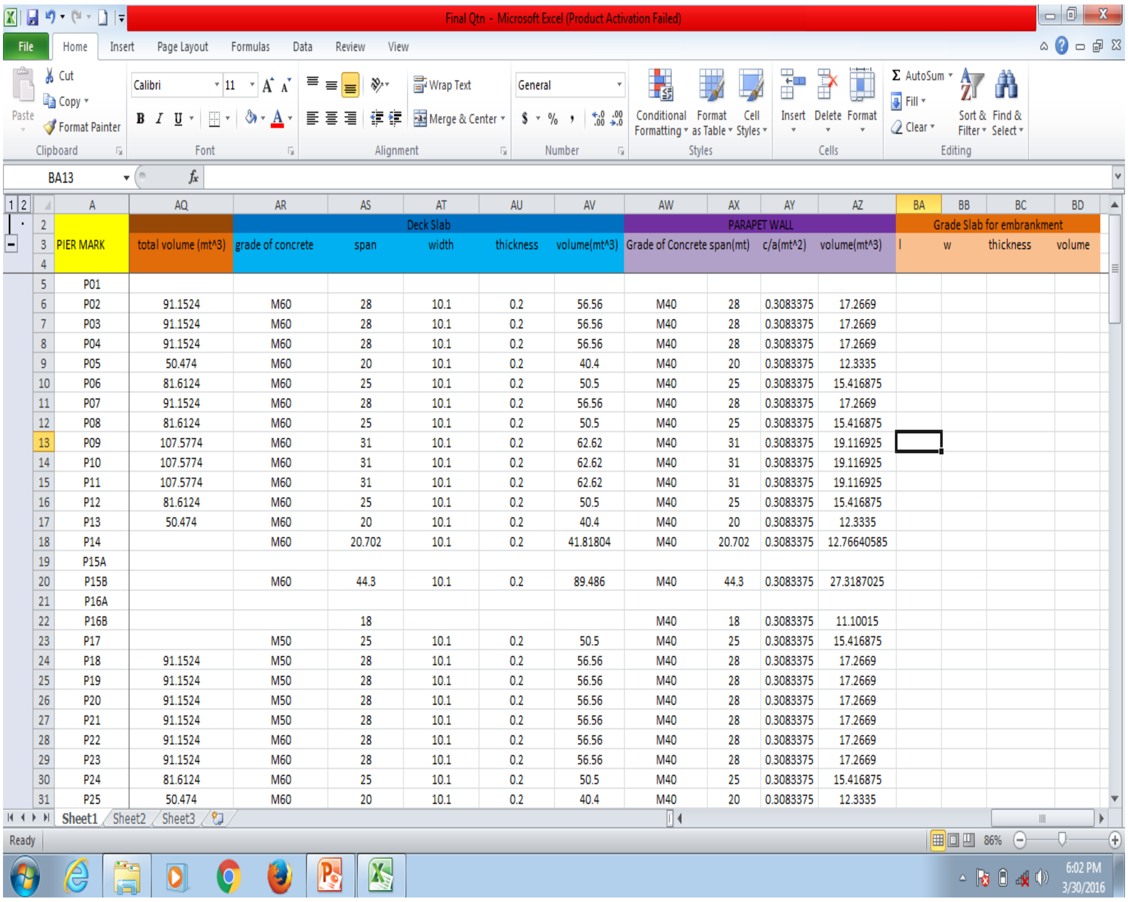
$C_f = W * c_t$(2)

Where C_f is the forecast total cost, W is the total units of work, and c_t is the average cost per unit of work experienced up to time t.

$C_f = C_t + (W - W_t) * c_t$(3)

Where, forecast total cost, C_f, is the sum of cost incurred to date, C_t, and the cost resulting from the remaining work (W - W_t) multiplied by the expected cost per unit time period for the remainder of the activity, c_t.

Estimation (Calculation Of Volume Of Concrete)



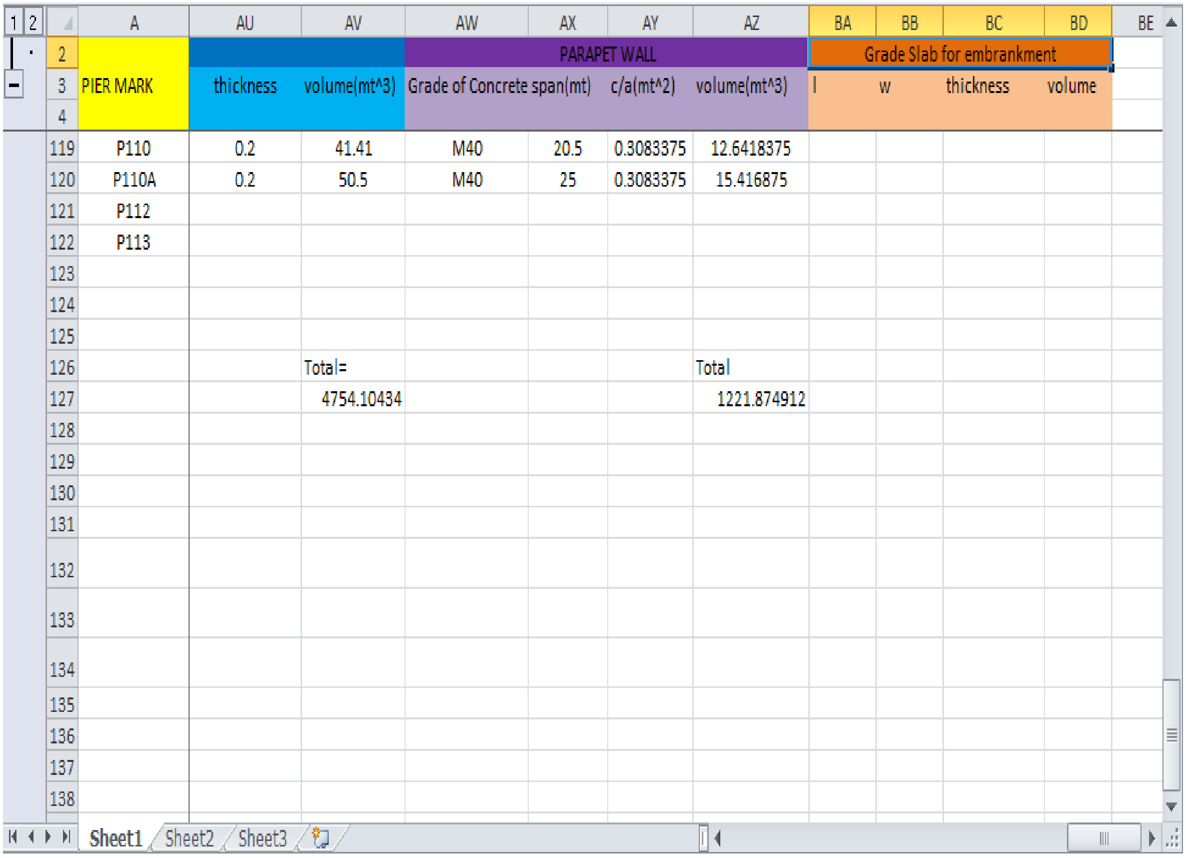
	A	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD
2			Deck Slab					PARAPET WALL				Grade Slab for embrankment			
3	PIER MARK	total volume (mt^3)	grade of concrete	span	width	thickness	volume(mt^3)	Grade of Concrete	span(mt)	c/a(mt^2)	volume(mt^3)	l	w	thickness	volume
4															
5	P01														
6	P02	91.1524	M60	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
7	P03	91.1524	M60	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
8	P04	91.1524	M60	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
9	P05	50.474	M60	20	10.1	0.2	40.4	M40	20	0.3083375	12.3335				
10	P06	81.6124	M60	25	10.1	0.2	50.5	M40	25	0.3083375	15.416875				
11	P07	91.1524	M60	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
12	P08	81.6124	M60	25	10.1	0.2	50.5	M40	25	0.3083375	15.416875				
13	P09	107.5774	M60	31	10.1	0.2	62.62	M40	31	0.3083375	19.116925				
14	P10	107.5774	M60	31	10.1	0.2	62.62	M40	31	0.3083375	19.116925				
15	P11	107.5774	M60	31	10.1	0.2	62.62	M40	31	0.3083375	19.116925				
16	P12	81.6124	M60	25	10.1	0.2	50.5	M40	25	0.3083375	15.416875				
17	P13	50.474	M60	20	10.1	0.2	40.4	M40	20	0.3083375	12.3335				
18	P14		M60	20.702	10.1	0.2	41.81804	M40	20.702	0.3083375	12.76640585				
19	P15A														
20	P15B		M60	44.3	10.1	0.2	89.486	M40	44.3	0.3083375	27.3187025				
21	P16A														
22	P16B			18				M40	18	0.3083375	11.10015				
23	P17		M50	25	10.1	0.2	50.5	M40	25	0.3083375	15.416875				
24	P18	91.1524	M50	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
25	P19	91.1524	M50	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
26	P20	91.1524	M50	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
27	P21	91.1524	M50	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
28	P22	91.1524	M60	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
29	P23	91.1524	M60	28	10.1	0.2	56.56	M40	28	0.3083375	17.2669				
30	P24	81.6124	M60	25	10.1	0.2	50.5	M40	25	0.3083375	15.416875				
31	P25	50.474	M60	20	10.1	0.2	40.4	M40	20	0.3083375	12.3335				

	A	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD
2				PARAPET WALL				Grade Slab for embrankment			
3	PIER MARK	thickness	volume(mt^3)	Grade of Concrete	span(mt)	c/a(mt^2)	volume(mt^3)	l	w	thickness	volume
4											
26	P20	0.2	56.56	M40	28	0.3083375	17.2669				
27	P21	0.2	56.56	M40	28	0.3083375	17.2669				
28	P22	0.2	56.56	M40	28	0.3083375	17.2669				
29	P23	0.2	56.56	M40	28	0.3083375	17.2669				
30	P24	0.2	50.5	M40	25	0.3083375	15.416875				
31	P25	0.2	40.4	M40	20	0.3083375	12.3335				
32	P26	0.2	38.38	M40	19	0.3083375	11.716825				
33	P27	0.2	60.6	M40	30	0.3083375	18.50025				
34	P28	0.2	34.34	M40	17	0.3083375	10.483475				
35	P29	0.2	40.4	M40	20	0.3083375	12.3335				
36	P30							584	10.5	0.3	61320.3
37	P31	0.2	16.362	M40	8.1	0.3083375	4.9950675				
38	P32							97	10.5	0.3	1018.50.3
39	P33	0.2	56.56	M40	28	0.3083375	17.2669				
40	P34	0.2	56.56	M40	28	0.3083375	17.2669				
41	P35	0.2	56.56	M40	28	0.3083375	17.2669				
42	P36	0.2	56.56	M40	28	0.3083375	17.2669				
43	P37	0.2	56.56	M40	28	0.3083375	17.2669				
44	P38	0.2	56.56	M40	28	0.3083375	17.2669				
45	P39	0.2	56.56	M40	28	0.3083375	17.2669				
46	P40	0.2	56.56	M40	28	0.3083375	17.2669				
47	P41	0.2	56.56	M40	28	0.3083375	17.2669				

Sheet1 Sheet2 Sheet3

	A	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD
2				PARAPET WALL				Grade Slab for embrankment			
3	PIER MARK	thickness	volume(mt^3)	Grade of Concrete	span(mt)	c/a(mt^2)	volume(mt^3)	l	w	thickness	volume
4											
65	P59	0.2	54.4895	M40	26.975	0.3083375	16.63480813				
66	P59E	0.2	36.36	M40	18	0.3083375	11.10015				
67	P59A	0.2	36.36	M40	18	0.3083375	11.10015				
68	P60	0.2	36.36	M40	18	0.3083375	11.10015				
69	P61										
70	P61E	0.2	30.5929	M40	15.145	0.3083375	9.339542875				
71	P61A	0.2	25.048	M40	12.4	0.3083375	7.64677				
72	P62	0.2	25.048	M40	12.4	0.3083375	7.64677				
73	P62A	0.2	25.048	M40	12.4	0.3083375	7.64677				
74	P63E	0.2	29.0274	M40	14.37	0.3083375	8.86161975				
75	P63	0.2	29.0274	M40	14.37	0.3083375	8.86161975				
76	P63A	0.2	29.0274	M40	14.37	0.3083375	8.86161975				
77	P64	0.2	24.18546	M40	11.973	0.3083375	7.383449775				
78	P64A	0.2	23.45624	M40	11.612	0.3083375	7.1608301				
79	P65E	0.2	54.4895	M40	26.975	0.3083375	16.63480813				
80	P65	0.2	54.4895	M40	26.975	0.3083375	16.63480813				
81	P66	0.2	60.6	M40	30	0.3083375	18.50025				
82	P67	0.2	60.6	M40	30	0.3083375	18.50025				
83	P68	0.2	56.56	M40	28	0.3083375	17.2669				
84	P69	0.2	56.56	M40	28	0.3083375	17.2669				
85	P70	0.2	56.56	M40	28	0.3083375	17.2669				
86	P71	0.2	56.56	M40	28	0.3083375	17.2669				

Sheet1 Sheet2 Sheet3



	A	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE
2				PARAPET WALL				Grade Slab for embrankment				
3	PIER MARK	thickness	volume(mt^3)	Grade of Concrete	span(mt)	c/a(mt^2)	volume(mt^3)	l	w	thickness	volume	
4												
119	P110	0.2	41.41	M40	20.5	0.3083375	12.6418375					
120	P110A	0.2	50.5	M40	25	0.3083375	15.416875					
121	P112											
122	P113											
123												
124												
125												
126			Total=				Total					
127			4754.10434				1221.874912					
128												
129												
130												
131												
132												
133												
134												
135												
136												
137												
138												

Sheet1 Sheet2 Sheet3

Fig. 1 Estimation of Concrete Volume

Total volume of concrete required for the above mentioned section = 22,745.5652 m^3.

Table 1: Cost Differences between Two Contractors for A Highway Pavement Contract

Items		Quantity	Unit price (Rs)	
			1	2
Mobilization		1	115,000	569,554
Removal, berm		8,020	1.00	1.50
Finish subgrade		1,207,500	0.50	0.30
Surface ditches		525	2.00	1.00
Excavation structures		7,000	3.00	5.00
Base course, untreated, 3/4"		362,200	4.50	5.00
Lean concrete, 4" thick		820,310	3.10	3.00
PCC, pavement, 10" thick		76,010	10.90	12.00
Concrete, ci AA (AE)		1	200,000	190,000
Small structure		50	500	475
Barrier, precast		7,920	15.00	16.00
Flatwork, 4" thick		7,410	10.00	8.00
10" thick		4,241	20.00	27.00
Slope protection		2,104	25.00	30.00
Metal, end section, 15"		39	100	125
18"		3	150	200
Post, right-of-way, modification		4,700	3.00	2.50
Salvage and relay pipe		1,680	5.00	12.00
Loose riprap		32	40.00	30.00
Braced posts		54	100	110
Delineators, type I		1,330	12.00	12.00
type II		140	15.00	12.00
Constructive signs fixed		52,600	0.10	0.40
Barricades, type III		29,500	0.20	0.20

Warning lights		6,300	0.10	0.50
Pavement marking, epoxy material				
Black		475	90.00	100
Yellow		740	90.00	80.00
White		985	90.00	70.00
Plowable, one-way white		342	50.00	20.00
Topsoil, contractor furnished		260	10.00	6.00
Seedling, method A		103	150	200
Excelsior blanket		500	2.00	2.00
Corrugated, metal pipe, 18"		580	20.00	18.00
Polyethylene pipe, 12"		2,250	15.00	13.00
Catch basin grate and frame		35	350	280
Equal opportunity training		18,000	0.80	0.80
Granular backfill borrow		274	10.00	16.00
Drill caisson, 2'x6"		722	100	80.00
Flagging		20,000	8.25	12.50
Prestressed concrete member				
type IV, 141'x4"		7	12,000	16.00
132'x4"		6	11,000	14.00
Reinforced steel		6,300	0.60	0.50
Epoxy coated		122,241	0.55	0.50
Structural steel		1	5,000	1,600
Sign, covering		16	10.00	4.00
type C-2 wood post		98	15.00	17.00
24"		3	100	400
30"		2	100	160
48"		11	200	300
Auxiliary		61	15.00	12.00
Steel post, 48"x60"		11	500	700
type 3, wood post		669	15.00	19.00
24"		23	100	125
30"		1	100	150
36"		12	150	180
42"x60"		8	150	220
48"		7	200	270
Auxiliary		135	15.00	13.00
Steel post		1,610	40.00	35.00
12"x36"		28	100	150
Foundation, concrete		60	300	650
Barricade, 48"x42"		40	100	100
Wood post, road closed		100	30.00	36.00
TOTAL			7008146.55	78,14,054.5

Here, both contractors are competing with each other for a highway pavement contract and we can see the contractor 1 is the one with the least estimate of cost of construction, so he bags the contract. There are certain instances where the contractors have a huge difference in the cost estimate for the same item. This differences can arise if the contractor has to i) transport materials from a long distance, ii) import materials that he doesn't have at that instance, iii) use heavy machinery, iv) use excess labour to avoid delays, etc.

Develop Mitigating Measures

- *Preventive measures*: These are precautionary measures that are put in place as a defense to the unwanted factors. Most of these measures are active measures that would be put in place during the planning stage of a project
- *Predictive measures*: Predictive measures are put in place in order to spot potential problems to the control process in the future so that they can be stopped from happening or be prepared for them should they happen.
- *Corrective measures*: These are measures that are utilized to mitigate the effect of the project control inhibiting factors by acting as a remedy. These measures are reactive measures that only act after the event. These measures are not pre-planned or well thought of measures, they are just discovered or invented on the spot or before the problem gets out of hand.

Measures To Control Construction Cost

- Proper Project Costing and Financing
- Competent Personnel
- Appropriate Scope Definition

- Proper Cost Control
- Risk Management during Project Execution
- Appropriate Contractual Framework
- Realistic Cost Estimation
- Efficient Resource and Time Management
-

Cost Of Quality

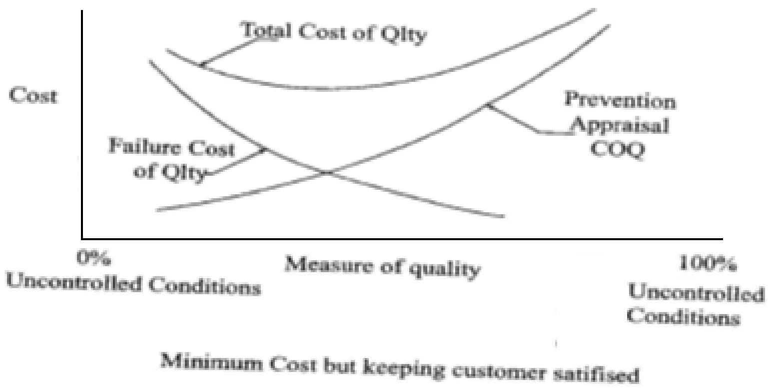


Figure: *Cost Benefit Model*

- ➢ Quality Cost = Control Cost + Failure Cost
- ➢ Control Cost = Prevention Cost + Appraisal Cost
- ➢ Failure Cost = Internal Failure Cost + External Failure Cost

Preventive Cost

There are costs arising from quality related activities required to subdue the negative deviations from the conformance specifications. These costs include:-

- Quality Planning
- Design Review
- Cooperation with sub-contractors
- Establishment and Maintenance of quality systems
- Training in inspection and control systems

Appraisal Cost

These are expenses incurred to determine whether a product, process or service conforms to the specified requirements or not. These costs include:-

- Incoming and in-process inspection and test
- Final inspection and quality analysis
- Procurement and calibration of testing and measuring equipment
- Vendor evaluation

Failure Cost

Failure costs are those resulting from non- adherence to specifications. These can be divided into internal and external failure costs.

VI. Conclusion

The cost management of construction project is a complicated system working and needs all employees' participating. Through pre-control, control in process, enterprises can strengthen the calculation and control of the project cost in all phases of construction, and can realize the goal of saving and reducing the construction cost. Only in effective cost management, construction enterprises can ensure to get the best economic benefits while the targets of quality, progress and safety are reached, and lay a good foundation for the sustainable development of them.

Cost forecasting or planning and scheduling is an effective tool of cost management, it is worthwhile to be learned and applied by engineering contractors during the construction project and with the development of information technology projects, cost estimating and scheduling will be more widely used in process of various construction projects.

To provide data for future cost management, an evaluation is often carried out to prepare a detailed cost analysis of the completed project and to develop lessons learned to improve future design decisions. The cost data captured should also be fed back in to the owner's database to inform future estimates and budgets. We should also include a review of energy performance of the building during occupancy, to ascertain if the data used was accurate for the actual performance.

Acknowledgement

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