COST MANAGEMENT IN CONSTRUCTION PROJECTS

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Abstract: The reality of most project scheduling applications is extremely complex; project managers must make task start decisions under different scheduling needs (such as smooth resource utilization profiles and resource constraints) and under conditions of uncertainty that sometimes extend beyond task durations. Resource Management is a difficult task due to inherent complexity of construction projects. The present study deals with resource planning for a fast-track project with constrained durations.
The study was carried out in two phases. In the first phase, I have been taken a plan of G+2 Residential building. From the plan I am estimated the quantities for various activities. According to the Standard Schedule Rates (CPWD) the manpower and cost required for various activities were estimated. By using Microsoft Project software project schedule was prepared. The requisite data was collected from the detailed drawings and prevailing site conditions.
In the second phase, a Resource(Cos)t Constrained Analysis was carried out by Resource Levelling for various activities by decreasing resources with increased duration to study the time-cost implications.

INTRODUCTION

1.0 General Introduction:

The term “Construction Project” refers to a high-value, time bound, and special construction mission with predetermined performance objectives. The project mission is accomplished within complex project environments, by putting together human and non-human resources in to a temporary organization headed by the ‘Project Management’.

Project Management is the Planning, Organizing, Directing and Controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives.

Due to the resource-driven nature of construction management, the construction manager must develop a plan of action for directing and controlling resources of workers, machines and materials in coordinated and timely fashion in order to deliver a project within the limited funding and time available. Hence, aside from a technology and process focus, a resource-use focus must be adequately considered in describing a construction method or operation in a project plan.

In general, construction projects are high value, and they employ huge resources of men, materials and machines. Major works involve heavy investments, say from a hundred crores of rupees to a few rupees, require high level of technology and need effective management of resources.

LITERATURE REVIEW

2.0 Introduction:

A brief review of the important aspects of the available literature pertaining to project management and resource levelling are presented in this chapter.

Khaled El-Rayes and Dho (2009) studied "**Resource Levelling in Construction Projects**". Construction schedules, generated by network scheduling techniques, often cause undesirable resource fluctuations that are impractical, inefficient, and costly to implement on construction sites. This paper presents the development of two innovative resource levelling metrics to directly measure and minimize the negative impact of resource fluctuations on construction productivity and cost. The first metric quantifies the total amount of resources that need to be temporarily released during low demand periods and rehired at a later stage during high demand periods. The second measures the total number of idle and non-productive resource days that are caused by undesirable resource fluctuations. The two new metrics are incorporated in a robust and practical optimization model that is capable of generating optimal and practical schedules that maximize the efficiency of resource utilization. An application example is analyzed to illustrate the use of the model and demonstrate its capabilities. The results of this analysis show that the present model and metrics are capable of outperforming existing metrics and eliminating undesirable resource fluctuations and resource idle time.

M. Easa, (1989) studied "**Resource Levelling in Construction**". Resource levelling is needed in construction to avoid the difficulties associated with the large variations in resource usage. This paper presents an integer- linear optimization model of resource levelling (single resource, continuous activities) which guarantees the optimal levelling. The objective function of the model minimizes the absolute deviations between the resource requirements and a uniform resource level, between consecutive resource requirements, or between the resource requirements and desirable non-uniform resource levels. The model requires as input the critical path method (CPM) scheduling results, from which the constraints and objective function of the model are established automatically by an interface program. Extensions of the model to multiple resources and trade-off of cost scheduling are suggested. The model is applicable to activity-on-arrow, activity-on-node, and precedence networks and is intended for small- to medium sized construction projects.

Tarek Hegazy (1999) studied "**Resource Allocation and Levelling using Genetic Algorithms we get Cost management**". Resource allocation and levelling are among the top challenges in project management. Due to the complexity of projects, resource allocation and leveling have been dealt with as two distinct sub problems solved mainly using heuristic procedures that cannot guarantee optimum solutions. In this paper, improvements are proposed to resource allocation and levelling heuristics and the Genetic Algorithms (GAs) technique is used to search for near-optimum solution, considering both aspects simultaneously. In the improved heuristics, random priorities are introduced into selected tasks and their impact on the schedule is monitored. The GA procedure then searches for an optimum set of tasks priorities that produce shorter project duration and better-levelled resource profiles. One major advantage of the procedure is its simple applicability within commercial project management software systems to improve their performance. With a widely used system as an example, a macro program is written to automate the GA procedure. A case study is presented and several experiments conducted to demonstrate the multi objective benefit of the procedure and outline future extensions.

Dho Heon Jun and Khaled El-Rayes (2011) studied "**Multi objective of Resource Levelling and Allocation during Construction Scheduling**". Construction scheduling techniques often generate schedules that cause undesirable resource fluctuations that are inefficient and costly to implement on site. This paper presents the development of a novel multi objective optimization model that is capable of measuring and minimizing these undesirable resource fluctuations to maximize resource utilization efficiency and minimize project duration while complying with all

precedence relationships and resource availability constraints. The model incorporates three main modules: (1) a startup module that calculates lower and upper bounds for the model decision variables; (2) a scheduling module that generates practical schedules and evaluates their performance; and (3) a multi objective genetic algorithm module that searches for and identifies optimal schedules. The model is integrated in a commercially available software system to facilitate its use and adoption by construction planners. An application example is analysed to illustrate the use of the model and demonstrate its new and unique capabilities in generating optimal trade-offs between maximizing resource utilization efficiency and minimizing the duration of construction projects.

PROJECT MANAGEMENT

3.0 Introduction:

3.1 Defining Construction Project Management:

It is impossible to define a complex operation such as Construction Management in a simple one-sentence. We will have to dissect the term and define its many facets.

3.1.1 Construction Projects:

In general, major construction works are time bound and employ huge resources of men, material and machines. Construction projects involve heavy investments from hundred crores of rupees to a few rupees. They require a high level of technology, and need an effective management of resources. The execution of major construction capital works is undertaken by projecting them that is, by organizing many simpler construction projects and performing the jobs to complete or achieve the goal or objective (major construction).

3.1.2 Project Management:

Project Management is the utilization of knowledge, skills, tools, and techniques to project activities in order to meet or exceed client needs and aspirations from a project. Meeting or exceeding client needs and expectations invariably involves balancing competing demands among:

- Scope, time, cost, and quality.
- Stakeholders with differing needs and expectations.

The term project management is sometimes used to describe an organizational approach to the management on-going operation. This approach is called management by projects, walking many conditions of on-going operations of projects in order to apply project management to them.

3.2.2 Objective of Resource Management:

Project management has been previously described as the judicious allocation of resources to accomplish project completion at maximum efficiency of time and cost. Manpower, equipment, and materials are important project resources that require close management attention. The supply and availability of these resources are seldom completely certain because of seasonal shortages, labor disputes, breakdowns, competing demands, and delayed deliveries. Nevertheless, if the project schedule is to be met, the work must be supplied with necessary men, equipment, and materials when they are needed and efficient use must be made of them. If shortage of resources materializes or are anticipated or if different job activities compete for the same limited

resource, it is a management responsibility to avoid or minimize the accompanying adverse effects.

The basic objective of resource management is to supply and support the field operations, so that a planned time schedule can be met and cost can be optimally controlled. The project manager is responsible to identify and schedule future requirements, so that field managers may obtain the resources at an appropriate time and place to employee these in the project. The real key to the efficient usage of labour and equipment is the consistent achievement of favourable production rates in the field. In this regard, project management and field supervision play complementary roles.

The scheduling and allocation of manpower, equipment, materials, finance and time frames are all interrelated. Resource management is devised to take the appropriate decision among these interrelating options.

A construction project site is usually far away from other projects and from the head office. Allocating a resource from one project to another is greatly constrained, and it always involves extra costs and time losses. Moreover, uncertainties in a construction project often limit the planning accuracy regarding when a resource is needed on a job site and/or when it can be released. Furthermore, some construction operations cannot be performed if a key or driving resource (e.g. crane) is not available. Contractors normally want to maximize the usage of key resources, but the utilization of other resources might be compromised. These factors must be considered while company-level resource allocation techniques are studied.

Project resource allocation, levelling, and optimization have been widely studied with common objectives such as meeting the needs of a project, maximizing the utilization productivity of resources, or minimizing a project's duration/cost. A contractor owns various resources such as equipment and crews. It may have insufficient or extra resources to meet the needs of its ongoing projects. Allocating available resources to ongoing projects is an important company-level business decision in order to maximize the overall business objective of the company.

3.2.3 Labour Requirements:

The management of construction manpower begins with the tabulation of labour requirements by trade for each project activity. Normally, an activity shown in a network can be further divided into a number of sub-activities to facilitate a labour estimate. The labour requirements to complete each activity are mainly filled up by estimates made by experienced professionals. Interviews with foremen, site engineers are helpful guides to estimate the manpower requirement. References like All India Standard Schedule of Rates by National Building Organization can also be used to estimate the manpower. An example of a tabulation sheet is presented in table.3.1.

Table 3.1. Time and labour requirement for each activity

Activity	Sub-activity	Unit	Quantity	Time (days)	Manpower	
					Unskilled	Skilled
Column casting in second floor	Column base	No.	52	6	5	5
	Steel work	MT	11.8	6	5	5
	Shuttering	Sqm	289.69	6	4	4

	Casting	Cu. m	34	6	28	-
	Deshuttering	Sqm		3	2	2
	Curing	No.	7	2	2	-

PROJECT ATTRIBUTES

4.0 Introduction:

This chapter presents details of an ongoing project in terms of project schedule, manpower required for different activities to carryout resource constrained analysis. The costs incurred in the project have also been presented.

4.1 Project Brief:

Spike Technologies is a software company situated on Whitefield - Bangalore. M/s Equips India is the project management consultants and M/s KNK Swamy and Co. is the contractors for the building project.

4.1.1 Project Details:

Name of the project	:	Construction of G+1 Building
Built up area	:	2500 Sft
Number of Storey's	:	Ground + one Floor
Floor to Floor height	:	3.0 m
Height of Plinth	:	0.50 m above Ground Level
Depth of Foundations.	:	1.50 m below Ground Level.
External Walls	:	250 mm thick including plaster
Internal Walls	:	150 mm thick including plaster
Parapet Walls	:	250 mm thick including plaster

4.1.2 Collection of drawings:

Generally, the collection of drawings from the company is very much useful for resource management in construction projects. From these drawings we can estimate the quantities of respective activities. These quantities plays key role for proceeding resource constrained analysis. Especially in this thesis construction of office building drawings were collected from Company Ltd. A plan of all the details of ongoing project is shown in Fig.4.1

4.3 Estimation of quantities:

After collecting the drawings from a company the quantities were estimated for various activities. The quantities such as earthwork excavation, concrete, steel etc., were estimated from the drawings.

4.4 Manpower Required:

Manpower output is the output quantity i.e., the quantity of work which can be done per day per person considering all safety and quality measures as required by client. This was calculated based on the CPWD Analysis of Rates and IS: 7272 (part I – 1974) recommendation for labour output constants for buildings work and also considering views based on the experience's and

thorough technical knowledge, of many project managers, architect's, engineer's and many contractor's who are experts and working in this field for many years.

4.5 Project Scheduling:

The schedule contains different types of activities with different durations based on their nature of work and quantities calculated from drawings. From the quantities man power required for various activities were calculated. Based on the quantities, manpower required and realistic durations in the current situations are taken in to account and durations are calculated. Based on the data obtained network diagram has prepared and relations assigned to activities calculated the critical path. The network diagram as shown in Fig 4.2. Also checked by the same network using MS project software. Finally, the total duration of the project was calculated by the MS project

4.5.1 Types of Relationships:

We can define relationships from the predecessor to the successor activity.

The relationships can be classified as

1. Finish-to-Start (FS)
2. Start-to-Start (SS)
3. Finish-to-Finish (FF)
4. Start-to-Finish (SF)

COST MANAGEMENT ANALYSIS

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

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

$C_f = C_t / P_t$ (1)

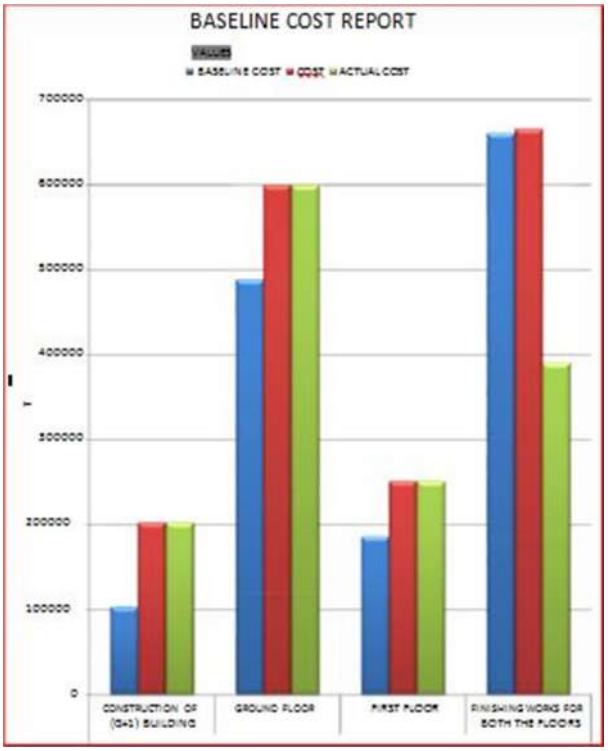
Where, total cost, C_f, C_t is the cost incurred to time t and p_t is the proportion of the activity completed at time t. $C_f = W * c_t$(2)

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.

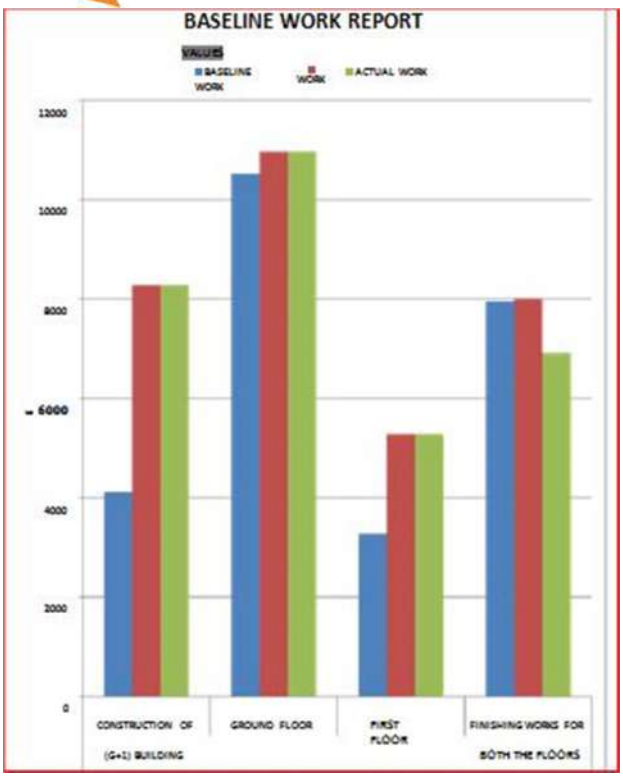
$C_f = C_t + (W - W_t) * c_t$(3)

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.

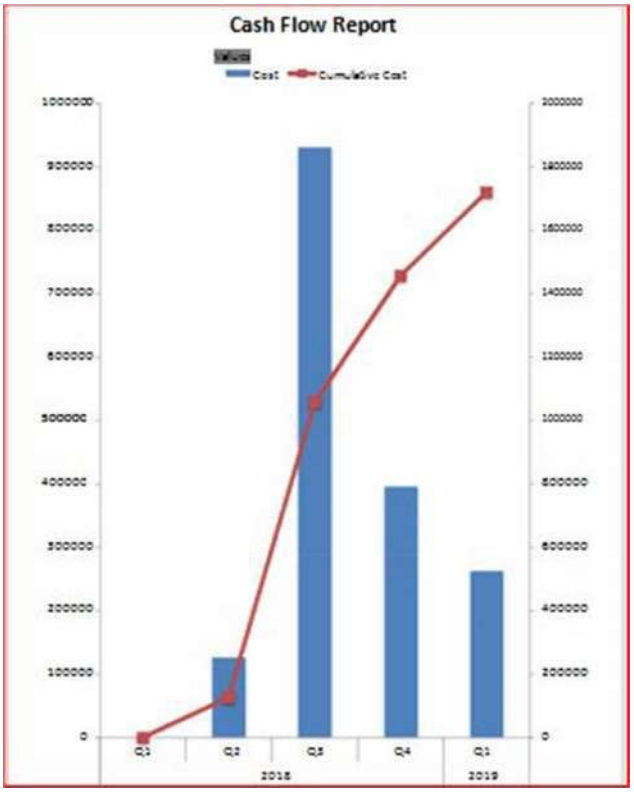
BASELINE COST REPORT



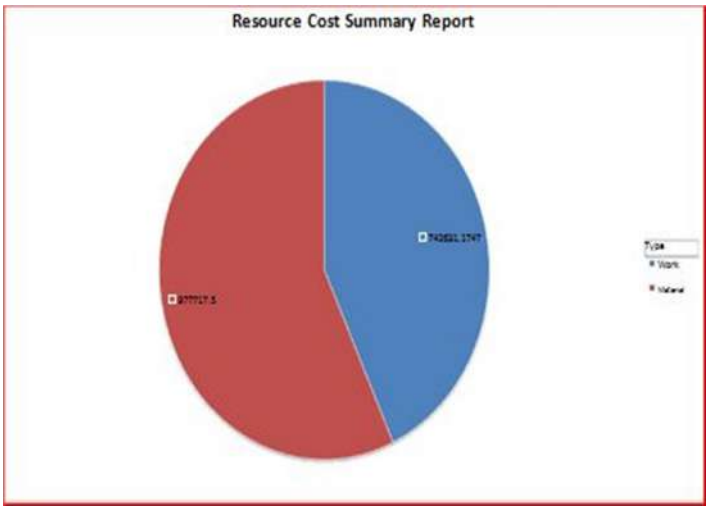
BASELINE WORK REPORT



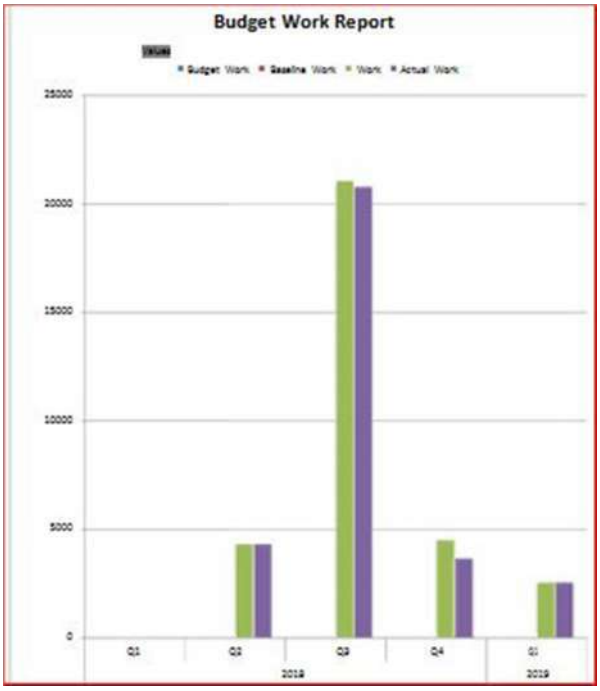
CASH FLOW REPORT



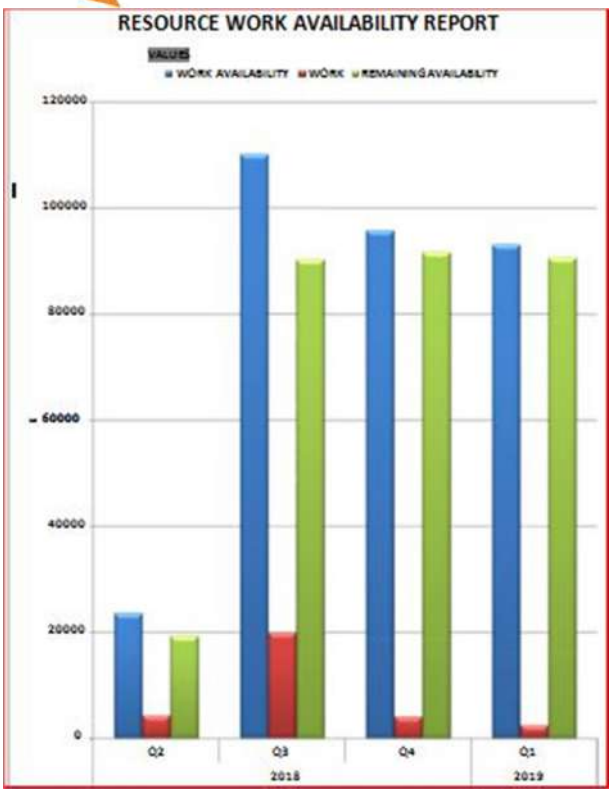
RESOURCE COST SUMMARY REPORT



BUDGET WORK REPORT



RESOURCE WORK AVAILABILITY REPORT



CASH FLOW AS OF WED 20-03-19
BAGLI (G+1)

	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter
G+1 HOUSE				
CONSTRUCTION OF (G+1) BUILDING				
CLEANING OF SITE	RS5,500.00			
EARTHWORK IN EXCAVATION	RS17,150.00	RS154,350.00		
1ST CLASS BRICK IN FOUNDATION		RS25,750.00		
GROUND FLOOR				
STRUCTURAL WORK				
MARKING	RS4,200.00			
DRESSING FOR PCC	RS33,990.00	RS12,360.00		
PLAIN CEMENT CONCRETE(P.C.C)				
REINFORCEMENT FOR FOOTING		RS55,700.00		
SHUTTERING FOR FOOTING		RS15,000.00		
RCC FOOTING		RS91,800.00		
BACK FILLING		RS30,500.00		

ANTI TERMITE TREATING				
MILESTONE 1				
SHUTTERING FOR PLINTH BEAM				
REINFORCEMENT FOR PLINTH BEAM			RS28,025.00	
RCC PLINTH BEAM			RS18,800.00	
COLUMN STARTER MARKING			RS7,250.00	
COLUMN STARTER CONCRETING			RS20,644.67	
REINFORCEMENT FOR COLOUMS			RS17,581.67	
SHUTTERING FOR COLOUMS				
RCC FOR COLOUMS				
SHUTTERING FOR SLAB				
REINFORCEMENT FOR SLAB				
ELECTRICAL CONDUTING				
RCC FOR SLAB AND BEAM				
COMPLITION OF GF SLAB				
MILESTONE 2				
FIRST FLOOR				
STUCTURAL WORK				
COLOUM STARTER MARKING	RS2,187.50			
COLOUM STARTER CONCREATING	RS20,003.03	RS50,696.97		
REINFORCEMENT FOR COLOUMS		RS11,020.50		
SHUTTERING FOR COLOUMS		RS38,000.00		
RCC FOR COLOUMS		RS48,590.00		
REINFORCEMENT FOR SLAB		RS46,340.00		
SHUTTERING FOR SLAB		RS10,800.00		
ELECTRICAL CONDUTING		RS960.00		
RCC FOR SLAB AND BEAMS		RS22,990.00		
COMPLEATION OF FIRST FLOOR SLAB				
FINISHING WORKS FOR BOTH THE FLOORS				
BLOCK WORK(100 MM THICK)	RS44,532.00	RS17,318.00		
BLOCK WORK(50 MM THICK)		RS50,350.00		
MILESTONE 3				
DOOR FRAME FIXING		RS52,000.00		
ELECTRICAL CONDUTING		RS7,500.00		
PLASTERING -CELLING		RS12,250.00		

PLASTERING - INTERNAL WALLS		RS11,600.00	RS2,900.00	
FLOORING(ROOMS)			RS260,900.00	
FLOORING(TOILETS)			RS9,875.00	
FLOORING(CORRIDOR/LOBBY AREA)			RS5,185.00	
FLOORING(STAIRCASE)			RS14,000.00	
RAILING WORKS(STAIRCASE)			RS5,880.00	
RAILING WORKS(BALCONY)			RS1,080.00	
FIXING OF DOORS& WINDOW SHUTTERS			RS23,600.00	
INTERIOR PAINTING			RS4,700.00	
ELECTRICAL FIXTURES			RS2,280.00	
SANITARY & WATER SUPPLY WORKS			RS11,380.00	
EXTERNAL PLASTERING			RS125,807.00	
CLADDING WORK				
EXTERNAL PAINTING			RS2,910.00	
TOTAL	RS127,562.53	RS765,875.47	RS562,798.34	

ADVANTAGES OF MS PROJECT SOFTWARE

To Clients

- To Finalize the Project Phasing or to finalize the Milestone schedule.
- The tentative budgets for the project phasing are available on the basis of which the project schedule can be phased out. This can give a financial viability analysis.

The advantages of MS Project Software to Project Management Consultants

- Project Management Consultants are representatives to Client & they are answerable to Client at any given point of time. PMCs need to provide an updated tracked schedule to the Client. The role of PMC is to update the schedule regularly and give a look-ahead schedule to the Client for every week, fortnight, month or quarter. The PMC also needs to provide the cash flow for the same.

The advantages of MS Project Software to Contractors

- MS Project gives a complete scope to the contractors to detail schedule his construction activities and assign resources accordingly. A contractor may detail the resource allotment up to no. of cement bags, steel quantity in MT, aggregate in brass, no. of labour, carpenter, fitter etc. This can also generate the cement & steel reconciliation reports instantly.

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.

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 defines 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

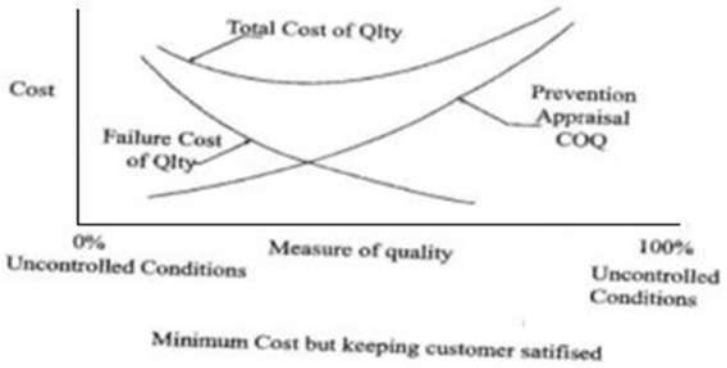


Figure: Cost Benefit Model

- 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.

CONCLUSION

The above given examples of software application are meant to provide insight to the software. The purpose is to make the software more approachable to all stakeholders of Real Estate Industry.

The concept of Time & Cost Management remain the as the key processes of the Project & Construction Management. Software is a mere medium to apply the concepts efficiently.

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.

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