Cost Control in Construction Project Using Primavera Project Planner

Mohammadreza Emadi Andani & Golsa Moshayedi

Technology University Of Mohsen Mohajer, Isfahan, Iran.
Email: emadi.mohammadreza@gmail.com

Abstract: The construction industry is one of the oldest and largest industries next to the agricultural sector. It is the second major field that contributes maximum to GDP of India. Any major construction project involves effective utilization of resources to complete the project successfully within the budgeted cost and stipulated time period. Construction planning plays the major role in the construction industry. The aim of the project manager is to execute the work in a planned and efficient manner within a fixed time and to the specified standards of quality. Planning, scheduling and controlling are the key requirements for effective project execution. Construction activities consist of large number of uncertainties due to various unpredictable factors such as climatic conditions, difficulties in the procurement of materials, and price fluctuations. These factors affect the planning techniques for optimization. Conventional planning techniques have contributed to the long drawn out projects with inflated costs and delayed utilization. In addition drastic improvements in design and technology have added new dimension to the construction industry. Construction of a project includes large numbers of activities with various interrelationships. These interrelationships among activities and Planning, scheduling and controlling of a project can be effectively done by using primavera project planner. This produces a detailed scheduling system and provides a means for planning, controlling project from conception to the completion of the project. It's useful for large scale construction, where more than or equal to 1000 activities has to be performed without disturbing each other activity in sequential manner. Further the budget control and manpower control san be assessed in proper way without giving any scope to unnecessary cost and time during execution of work. This tool is useful for all construction professional to accomplishment project in most organized way. Finally can say, project manager can manage the project with combination of knowledge and primavera project planner as a tool to get best result in control of project and finish the project on time and less than estimated cost.
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1. Introduction

Construction industry is a major economic activity in India and any country. Construction activities contribute annually about 10% of gross national product (GNP), thus it is playing a major role in the development of national economy. On an average about 50% of total expenditure of five year plan is invested in construction works because development plans for every sector of our economy involve construction activities.

Construction plays a major role in all development sectors like agriculture, irrigation, housing, manufacturing and transportation. The scope and volume of construction industry can be directly linked with the size and population of the country. With an ever increasing population, the need for housing and industry also increases. From all this, the national development is inseparably linked to development in the construction activities.

Construction industry is an important index for social and economic development of the nation. Construction activities are not only limited to the physical aspects involving men, materials, machineries and cost but also covers the entire activities of the project from conception to completion of the project. Construction activities are getting more complete day to day due to rapid improvement in technology. Cost, schedule, and quality are three major measures for construction project performance assessment. Among these three measures, cost and schedule are objective and quantitative, while quality is somewhat subjective and qualitative. In addition, cost and scheduling are closely interrelated, because they share a lot of common data in their controlling processes. Therefore, integrating cost and schedule control functions provides an effective tool for monitoring the construction process. Many researchers have emphasized the benefits of this integration and several different methodologies combining cost and schedule control data have been developed.

In order to meet the present day requirements it is necessary to complete the project within stipulated time, estimated cost and specified standards of quality. To complete the project within the specified time, scheduling with effective management is necessary. The aim of the project manager is to execute the

project in and efficient manner within a fixed time, estimated cost and specified standards of quality. Scheduling is a management tool used as a basis for decision making. Construction scheduling is an important aspect of construction. A schedule consists of different activities, dependencies, durations, constraints including bar charts, histograms, and progress curves.

Project scheduling and controlling involves breakdown of a project into activities, allocating resources and optimize their use. A work breakdown structure (WBS), is an effort estimate for each task, and resource list availability for each resource. It is a result oriented hierarchical tree that captures all the works in an organized way. Construction project exhibit complex inter relationships between schedules and costs. Although the inter-dependency between schedule and cost is obvious, it is rare to find project control systems that integrate cost and schedule control functions. To support construction process management effectively, a good system is needed to collect quality data in a timely fashion and for future planning of new projects. A majority construction projects employ some method of cost and schedule control. Still, many projects suffer from ineffective control due to inefficient flow of information. This inefficiency is a fundamental problem in construction management. Specifically, the quality of information flowing in the control system is the essence of the problem.

Rasdorf and Abudayyeh (1991) stressed the development of automated data-acquisition systems that utilize advanced information technology in their research modeling a relational database for work packages. Advance information technology is a definite solution and a driving force for the recent increasing interest in integrated cost and schedule control worldwide.

Cost control is one of the most important management functions in construction industry. The primary objective during the construction process is completing the project on time and within the budge while meeting the established quality requirements and specifications. To do so, requires a substantial focus on managing the construction process. However, managing a construction process is impossible without a plan and a control system. A plan establishes goals for a project schedule, cost and resource use as well as the tasks methods for carrying out work. The plan is developed based on the historical data as well as past experience with similar projects. On the other hand, a control system collects actual data on a project schedule and resource use, compares existing progress to the planned schedule to highlight potential problem areas needing special attention and makes decisions based on analysis results.

Construction companies need an adequate cost control system to improve their profitability and productivity. Cost control enables the firm to make decisions if the measurements do not comply with the initial targets. Control is considered the last logical step in management. During the control stage, the level of performance is compared with the planned objectives to find any deviation and consequently act on it. Cost control is conceived to ensure that costs stay in line with the planned needs established by the company to achieve economic targets. Every organization needs information about costs in order to plan, evaluate decide and budget among other purposes.

During the execution of a project, procedures for project control and record keeping become indispensable tools to managers and other participants in the construction process. These tools serve the dual purpose of recording the financial transactions that occur as well as giving managers an indication of progress and problems associated with a project. The task of project control systems is to give a fair indication of the existence and the extent of such problems. Project control procedures are primarily intended to identify deviations from the project plan rather than to suggest possible areas for cost savings. This characteristic reflects the advanced stage at which project control becomes important. The time at which major cost savings can be achieved is during planning and design for the project. During the actual construction, changes are likely to delay the project and lead to inordinate cost increases. As a result, the focus of project control is on fulfilling the original design plans or indicating deviations from these plans, rather than on searching for significant improvements and cost savings. For cost control on a project, the construction plan and the associated cash flow estimates can provide the baseline reference for subsequent project monitoring and control. For schedules, progress on individual activities can be compared with the project schedule to monitor the progress of activities. The final or detailed cost estimate provides a baseline for the assessment of financial performance during the project. To the extent that costs are within the detailed cost estimate, then the project is thought to be under financial control. Overruns in particular cost categories signal the possibility of problems and give an indication of exactly what problems are being encountered. One of the principle objectives of most organizations is that of achievement at minimum cost. This contributes to the one essential, though not exclusively so, of all business enterprises, that of profit. Profit in simple terms is what is left after all income accruing to the enterprise has been received and all of the costs or outgoings have been paid, for all construction projects,

cost must be monitored and controlled, whether from the point of view of owner, designer and contractor.

Cost control, may be defined as the regulation, by executive action, of the cost of carrying out the various activities, which go to making up a project or a contract. It is necessary at all stages of activity with which costs are associated to distinguish between cost control and analysis, and cost optimization. The former has been defined above and cost analysis and costing enable the detection of favorable and unfavorable variances against standards, which are set for the measurement of performance and expenditure.

There are some significant problems, which arise when considering the particular form of project cost control to adopt. Perhaps, the most significant of these concerns the cost of installing and operating the system itself. The cost of providing a means of collecting basic data, usually in the form of the hours worked by individual men on a daily basis, can be considerable. The hours which have been collected must be allocated, perhaps broken down into smaller groups as a result of investigation, converted into money terms, compared with the established standards, and then sundry reports to meet the needs of the management must be prepared.

Methodology

When suchpredictions and analysis are included, project cost management will include additional processes and numerous general management techniques such as return on investment, discounted cash flow, payback analysis, and others.

2. Resource Planning

Resource planning involves determining what physical resources (people, equipment, materials) and what quantities of each should be used to project activities.

Expert judgment will often be required to assess the inputs to the Resource Planning. The output of the resource planning process is a description of what types of resources are required and in what quantities for each element of work breakdown structure.

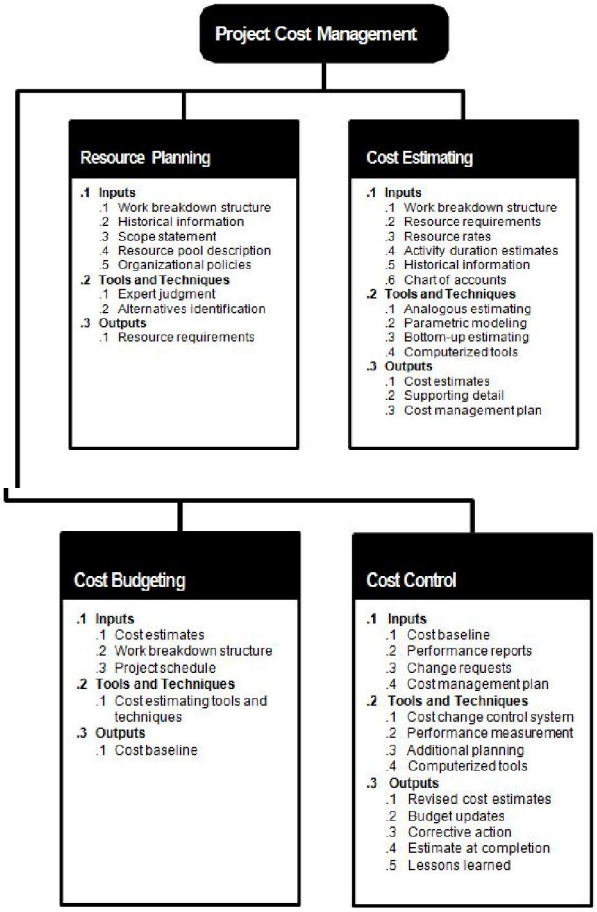

Figure 3.1 Project Cost Management Overview

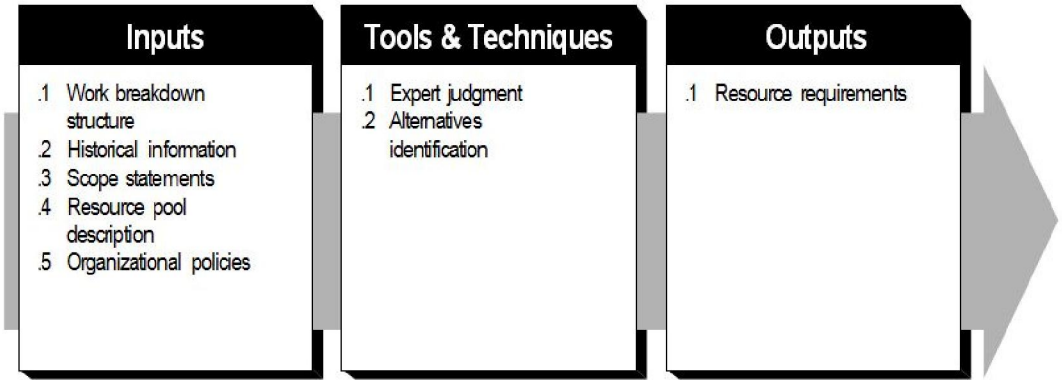

Figure 3.2 Resource Planning Overview

3. Cost Estimating

Cost estimating involves developing an approximation (estimate) of the costs of the resources needed to complete project activities.

When a project is performed under contract, care should be taken to distinguish cost estimating from pricing. Cost estimating involves developing an assessment of the likely quantitative result-how much will it cost the performing organization to provide the product or service involved. Pricing is a business decision-how much will the performing organization charge for the product or service that uses the cost estimate as but one consideration of many.

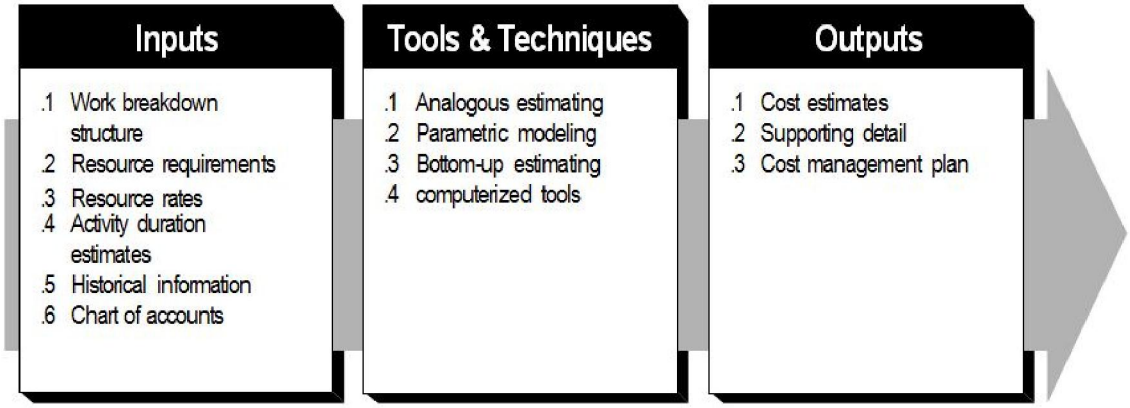

Figure 3.3 Cost Estimating Overview

4. Inputs to Cost Estimating

4.1. Work breakdown structure

The WBS will be used to organize the cost estimates and ensure that all identified work has been estimated. The Work Breakdown Structure (WBS) is an estimating tool that defines a project in terms of its deliverables. The WBS also provides a method for breaking down deliverables into meaningful units of work. With this breakdown, you establish the work hierarchy and create a foundation for the other elements of the estimating process.

5. Resource requirements

The output of the resource planning process is a description of what types of resources and what quantities for each element of the work breakdown structure are required. If a resource requirement cannot be fulfilled, the activity requiring the resource will fail and potentially cause the simulation to stop prematurely. If more resources than the required number are available to perform the activity, a sufficient number of resources is randomly selected for allocation to the activity.

6. Resource rates

The individual or group preparing the estimates must know the unit rates (e.g., staff cost per hour, bulk material cost per cubic yard) for each resource in order to calculate project costs. If actual rates are not known, the rates them-selves may have to be estimated.

7. Activity duration estimates

Activity duration estimating represents the act of quantifying estimating the amount of time that it is anticipated the activity will take to complete. This phase of the project, that which consists of the estimating of the amount of time needed to complete all individual schedule activities, typically and traditionally takes place before a project is kicked off, during the conception phase, however, it is possible for the actual activity duration estimating period to take place later, perhaps close to or even slightly after the project has officially kicked off, however, even in those cases a draft or preliminary estimation has typically been made.

8. Historical information

Information on the cost of many categories of resources is often available from one or more of the following sources:

8.1.1. Project files: One or more of the organizations involved in the project may maintain records of previous project results that are detailed enough to aid in developing cost estimates.

8.1.2. Project team knowledge: The individual team members of the project team may remembers previous or actual estimates.

9. Output for Cost Estimating

1. Cost estimates

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. Cost must be estimated for all resources that will be charged to the project. They may be presented in summary or detail.

2. Supporting detail

The supporting detail represents a logical and comprehensive explanation for how the cost estimates were derived.

The supporting detail illustrates how the cost estimate was created and includes a description of the activity's scope of work, as well as any assumptions and constraints.

Supporting detail for the cost estimates should include:

• A description of the scope of work estimated. This is often provided by a reference to the WBS.

• Documentation of the basis for the estimate, i.e., how it was developed.

• Documentation of any assumptions made.

• An indication of the range of possible results, for example, $10,000 ± $1,000 to indicate that the item is expected to cost between $9,000 and $11,000.

3. Cost management plan

The cost management plan describes how cost variances will be managed. It is a subsidiary element of the overall project plan.

8.2. Cost budgeting

The budget relates the expected costs and revenue with the time progress. The master control estimate prepared during the project planning stage is called the *original budget*. Each work package is budgeted with its database, containing the scope of work, resources, costs, the quality, time and the performance responsibility. Original budget is revised, if the situation demands. There is a fundamental difference in the use of the terms budget, standard, commitment and value, with respect to a work package.

1. Budget reflects the expected costs of performance under expected conditions.

2. Standard stands for the costs achievable under efficient operating conditions.

3. Commitment marks the booked cost of resources utilized consumed or expected.

4. Value of work performed implies the monetary value of the work completed. In contracted projects, it is equal to the value of the work done at contract rates.

The methods for measuring project budgeted performance will described in next chapter.

8.3. Cost Control

Cost control is concerned with (a) influencing the factors which create changes to the cost baseline to ensure that changes are beneficial, (b) determining that the cost baseline has changed, and (c) managing the actual changes when and as they occur. Cost control includes:

• Monitoring cost performance to detect variances from plan.

• Ensuring that all appropriate changes are recorded accurately in the cost baseline.

• Preventing incorrect, inappropriate, or unauthorized changes from being included in the cost baseline.

• Informing appropriate stakeholders of authorized changes.

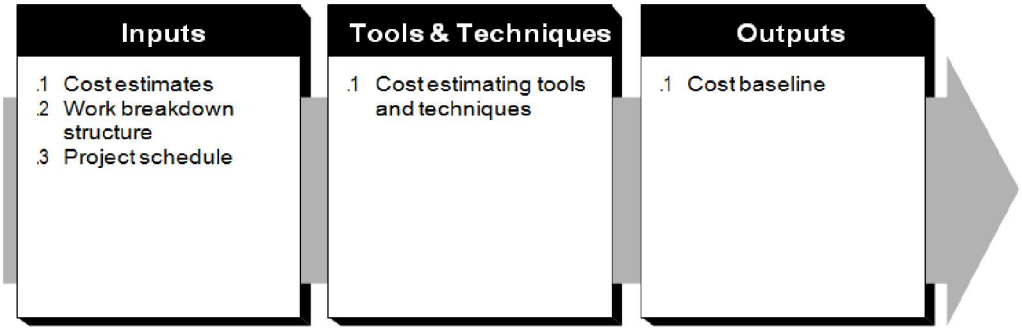

Figure 3.4 Cost Budgeting Overview

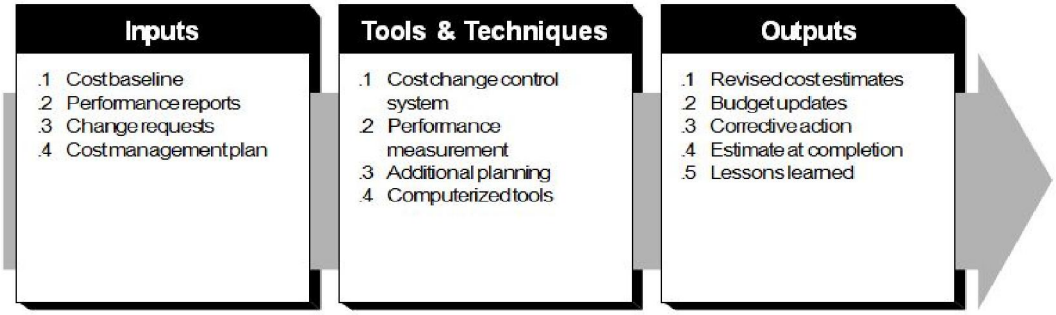

Figure 3.5 Cost Control Overview

Tools and Techniques for Cost Control

Project cost escalation and cost management are clearly two of the most important management concerns in the intensely competitive environment of the construction industry. Consequently it is very important for the management to detect at an early stage of project the actual or potential cost overruns. To remain competitive while generating profit, management needs to identify and adopt innovative cost management strategies. These strategies allow them to identify and control early on factors that might adversely impact the cost of a project.

Cost control during the construction process is vital to ensure the success of a project. The construction of a complex structure is a major undertaking and typically has people specifically responsible for cost control. Construction and cost engineering professionals have long recognized the need for improvements in the area of cost control. Managing costs includes estimating, scheduling, accumulating and analyzing cost data, and finally implementing measure to correct a cost problem. There are several cost control techniques that are used by the construction industry in varietydegrees. These are exception reporting, trend analysis, earned value, range estimating, and forecast unit cost. Except for perhaps earned value, these cost control techniques tend to focus on variances in line items once the cost overrun has been discovered. However none of these methods considers at a macro level the influence of many important factors such as wastage, project management practices, change orders and error / rework on the project cost. Existing methods of cost control focus on identifying and controlling cost components that have already experienced a cost escalation. In other words, existing methods of cost-control relate to symptoms rather than the cause.

9. Variance Analysis Approach

Variance analysis can be used during the schedule - monitoring process to compare target dates with actual start and finish dates, thereby detecting any deviations from the plan and allowing to implement corrective solutions. Variance analysis is widely used to measure the performance of a project's cost, schedule, resources, quality, scope, and risk. A variance in any of these areas is the difference between what is planned and what actually happens. Variance analysis in project scheduling is most often used to measure deviations in cost and schedule from the planned budget.

- *Cost variance analyzes* any deviations from the planned dollar budget.
- *Schedule variance analyzes* any deviations from the planned completion dates of an activity.

Cost and schedule variances are both calculated based on costs and are represented as a function of cost. When applying variance analysis, figures are obtained from the performance measurement information in project plans and work results. The three key areas for calculating variance are: earned value (EV), actual cost (AC), and planned value (PV).

- *Earned value* (EV) is all the budgeted costs for an activity completed during a period of time. It includes any overhead costs.
- *Cost variance* (CV) examines an activity by comparing the difference between its estimated cost and the actual cost.
- *Planned value* (PV) is all the approved, estimated costs for the work scheduled to be completed for an activity during a period of time.

If the cost variance shows a negative value, the activity costs more than what was estimated. If the schedule variance shows a negative value, the activity is behind the estimated schedule. Depending upon the threshold or contingency, the negative values may be a cause for concern and must be reported. If contingencies were created in the budget to handle cost overruns, then a negative value in scheduling or in costs may not be a cause for concern. When monitoring a project schedule, you can use variance analysis to identify any deviations from the plan and to ensure that your project does not fall behind schedule. So, the traditional approach to project cost control involves a comparison of the actual cost with the budgeted cost to determine the variance.

(5.1) *Variance for the period = Actual cost in the period – Budgeted cost in the period.*

The variance analysis approach is inadequate for project cost control for the following reasons:

1. It is backward looking rather than forward looking. It tells only what happened in the past but does not answer the questions like, what will happen in the future? Is the rate of work accelerating of decelerating?
2. It does not use the data effectively to provide integrated control. The traditional variance analysis shows whether in the time period under analysis more or less resources were expended than budgeted. However, it does not indicate the value of work done. This information is vital for purposes of control.

Performance Measurement

An important part of cost control is to determine what is causing the variance and to decide if the variance requires corrective action. Performance measurement techniques help to assess the magnitude of any variations which do occur.

Computerized Tools

Computerized tools such as project management software's and spreadsheets are often used to track planned costs vs. actual costs, and to forecast the effect of cost changes. One of such tools is the primavera project manager.

Case Study 1 Construction of Highway and Discussion

The first case study and main one is a construction of highway located on west of Iran between Azadegan, Yadavaran, Shalamcheh and Jofairr cities. This is one of the biggest highway projects in Iran by cost of Rial 43,193,009,048 duration of 1321 days and 165 km length. The project is scheduled to start on 20Jun 2009 and finish on 15 Aug 2012 the project is divided into four phase and all phase have same contractor and the project is controlled by Haraz consultant company. Employer of project is government of Iran and financial source of project is oil industry.

The project was chosen and all data collected. After inspection of all material, project WBS is prepared. By help of WBS project is divided in to 5 divisions and each one of that has 6 subdivisions. Each subdivision has some another subdivision and totally project divided into 56 levels. Finally activities of the project under each division are assigned and data entry into P6.7 is started. The project includes 265 activities.

By applying Primavera project planner (P6.7) project duration reduced by 135 days and total coat of project also reduced by Rial98,547,254. It means the total cost of project is Rial 43, 094,461,794, and duration is 1186 days after applying P6.7.

Case Study 2, Construction of Official Building and Discussion

The second case study is a governmental building located on Isfahan with two floor and a plinth area of 1200sqm. The project is scheduled to start on 20 Jun 2011 and finish on 09 Jun 2012. Primavera project planner as a project management has been effectively applied for this project. The project includes:

- 1200sqm plinth area
- 2200sqm road wall
- 15000sqm construction of access road
- 5000aqm green area

WBS of the project is including 3 main division and 13 sub division. Project includes 62 activities. The present project is scheduled to complete within 365 days by total cost of Rs20,919,383.

By applying Primavera project planner (P6.7) project duration reduced by 30 days and total coat of project also reduced by Rs34,0384. It means the total cost of project is Rs20,578,999 and duration is 335 days after applying P6.7. To enter data in to p6.7 The steps involved are as follows:

Step 1: Identification of the various activities involved in the construction of a project.

Step 2: Calculating the material and labor required for each activity and then arriving at the duration of each individual activity.

Step 3: The project start date is decided and the activity description and the durations are incorporated into the P6 software. The relationship between the activities is described.

Step 4; The various resources required for each activity is first defined in P6. The resources are then assigned to each activity.

Step 5: A cost account for each resource is created in P6. The cost for each resource per unit required is also defined in the cost account. From this, the cost for each activity is calculated by the software and hence we arrive at total cost of the project.

Step 6: We get a total estimated cost of the project from above. This report can be taken as a baseline to compare the project with the actual work. If any deviation found, necessary action may be taken in order to stay on track with the estimated cost. P6 generates various standard project reports that describe the total project effectively. Some of the reports generated by P6.7 are as follow:

10. Results

Cost control is one of the most important management functions in construction industry. The primary objective during the construction process is completing the project on time and within the budget while meeting the established quality requirements and specifications. To do so, requires a substantial focus on managing the construction process. Construction companies need an adequate cost control system to improve their profitability and productivity. Cost control enables the firm to make decisions if the measurements do not comply with the initial targets. Control is considered the last logical step in management. For cost control on a project, the construction plan and the associated cash flow estimates can provide the Cost control data gives the day-to-day cost is exceeding the estimated one.

A governmental building located at Isfahan with an area of 1200sqm is taken as the present case study. It is scheduled to start on 20 Jun 2011 and ends on 09 Jun 2012. Primavera project planner, management software is applied to the present case study. By applying this software, it is possible to schedule the project, thus known the total duration of the project. The present project is scheduled to complete within 11 months. Also the total cost of the project which was estimated is Rs20,578,999.

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cost of project is Rs20,578,999 and duration is 335 days after applying P6.7.

The next case study and main one is a construction of highway located on west of Iran between Azadegan, Yadavaran, Shalamcheh and Jofairr cities. This is one of the biggest highway projects in Iran by cost of Rial 43,193,009,048, duration of 1321 days and 165 km lengths. The project is scheduled to start on 20Jun 2009 and finish on 15 Aug 2012, the project is divided into four phase. By applying Primavera project planner (P6.7) project duration reduced by 135 days and total coat of project also reduced by Rial98,547,254. It means the total cost of project is Rial 43, 094,461,794, and duration is 1186 days after applying P6.7.

The total cost of the project can be estimated initially before the project is under actual execution. When the actual work is under execution, there may be a deviation from the estimated budget. The estimated budget serves as a baseline during the actual execution. If any deviations, necessary action may be taken to stay on track with the estimated budget.

P6 support cost accounts so we can easily exchange data without financial system. It enables us to establish budgets and forecast estimates-to-complete for each cost account level. We can then tract actual for this period and to date. Project performance is measured and compared to plan using earned value analysis and cost and schedule variances. By comparing actual performance to original plans, we can improve our processes and increase the accuracy of future estimates. By using P6, few standard reports have been developed. Some of the tabular reports are the Scheduling report, Summary by activity report, Detailed by resource, Summary by cost account report, Summary by resources report and Detailed by Activity resources.

All the above mentioned tabular and graphical reports are really of great help in controlling the cost of the project. They describe the position of the project clearly. Thus it is helping to take proper timely decisions. These reports are considered as the baseline references and compared with the actual work in progress. If any deviations found, then corrective actions are to be taken to keep the project in track.

Scope of Future Study

While taking as this project it was aimed to make it a pilot project which will give some ideas about similar project in future to be followed with respect this project. Also it provide some idea about different area of managing cost in construction industry. Moreover this thesis is helpful to future study in the field of cash flow analyses. Primavera6.7 project planner followed in execution of project right from beginning to the end will prove cost effectiveness.

Thus it may be seen that to cover the cost effectiveness aspect in construction projects various skills and knowledge are to be applied judiciously at every stage to achieve its goals.

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