

VALUE MANAGEMENT

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Abstract— Liquid storage tanks constitute an important component of life line systems such as water distribution system, petroleum plants etc. Seismic design of liquid storage tanks requires knowledge of sloshing frequency of liquid and hydrodynamic pressure on the wall. This in turn, requires proper analysis of fluid-tank interaction under seismic excitation. In the design codes, mechanical analogs of tank-fluid system are commonly used to obtain the sloshing frequency, hydrodynamic pressure and design seismic forces. Such mechanical analogs are and developed for simple geometries, like circular and rectangular tanks. However, for tanks of other shapes and for tanks with internal obstructions, there are a very few studies on the mechanical analogs. In the present paper, experimental and numerical study is taken up to obtain the sloshing frequency of liquid contained in tanks of other shapes and tanks with internal obstructions. The experimental study is done on laboratory models of tanks, which are excited using an Electro-Magnetic Shake Table. The numerical study is done with the help of finite element model of tank-fluid system using ANSYS software. A comparison of experimental and numerical results is given.

Keywords- Fluid-tank interaction, Sloshing frequency, tanks with obstruction, tanks of other shapes, ANSYS

1.1 Introduction

Earned Value analysis is a method of performance measurement. Earned Value is a program management technique that uses “work in progress” to indicate what will happen to work in the future. Earned Value is an enhancement over traditional accounting progress measures. Traditional methods focus on planned accomplishment (expenditure) and actual costs. Earned Value goes one step further and examines actual accomplishment. This gives managers greater insight into potential risk areas. With clearer picture, managers can create risk mitigation plans based on actual cost, schedule and technical progress of the work. It is an “early warning” program/project management tool that enables managers to identify and control problems before they become insurmountable. It allows projects to be managed better – on time, on budget. Earned Value Management System is not a specific system or tool set, but rather, a set of guidelines that guide a company’s management control system. In the case of cost overrun, project management team may execute a value engineering program for cost reduction either reducing scope and quality

in some sections of project or providing additional budget to cover overrun cost. Similarly, for time overrun case, they may plan some program such as fast tracking or time crashing for time reduction. Therefore, the role of EVM as well as correct and on time forecasting is very important to achieve project goals. This research includes implementation and improvement on EV to achieve a forecasting EAC based on statistical and econometrics techniques and traditional EV indexes as well.

The Earned Value Analysis (EVA) is a valuable technique to determine real gains and losses. EVA provides means to balance gains/losses, optimize the balance and maximize the gains. EVA is a powerful tool to control simultaneously physical and cost performance. EVA provides an integrated schedule (time), progress, and cost management, related to scope and procurement, quality, and risks.

Harold Kerzner (1998) considers EVA a relevant maturity differential in project management. To manage costs using EVA is called “manage with open eyes” because the manager can clearly see what was planned, what was performed, and the actual costs. This is a powerful tool in the decision making process. In the day-by-day of the manager, EVA provides “alarm” signs and allows decisions that keep the project on time and on budget.

The cost management in Construction Projects needs the planning of budgeted costs and their control. This is related to all the knowledge areas in the project. The actual costs are related with the work performed, but the work performed is not often exactly equal to the work scheduled. The solution is the control, measurement and determination of the budgeted cost of the work performed and compare it to the actual costs. One difficulty is the determination of the proper accounting system and deal with scope changes. The solution is an appropriate WBS – Work Breakdown Structure, and a suitable account plan. The solution requires distinguishing the financial control and cost control

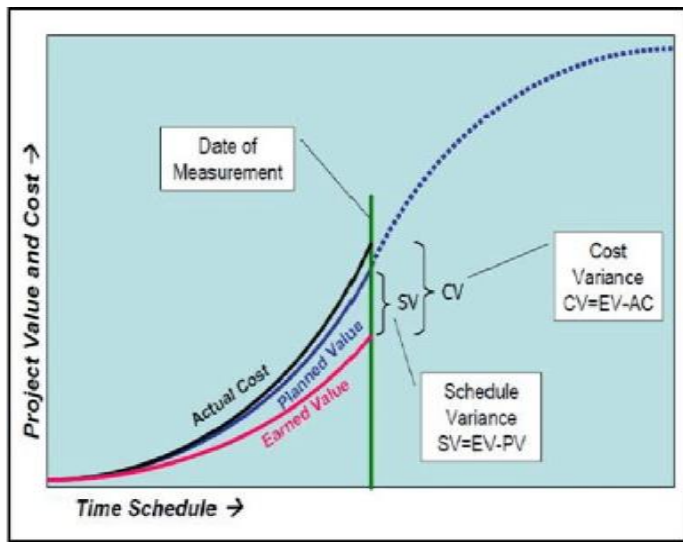


Fig 1.1: standard Earned Value analysis graph

1.2 EARNED VALUE ANALYSIS –CONCEPT

Earned Value is a program management technique that uses “work in progress” to indicate what will happen to work in the future. EVA uses cost as the common measure of project cost and schedule performance. It allows the measurement of cost in currency, hours, worker-days, or any other similar quantity that can be used as a common measurement of the values associated with project work. EVA uses the following project parameters to evaluate project performance:

- Planned Value
- Earned Value
- Actual Value

As noted, there are many ways to calculate the EV, PV and AC of work packages that are in progress. Comparison of those figures can serve to identify specific work packages in which performance and progress is inadequate or advanced, which will hopefully lead to remedial action by the project manager and team. Cost and schedule performance should be measured and analyzed as feasible with regularity and intensity consistent with project management need including the magnitude of performance risk. Analysis should be progressive and should follow the principle of management by exception. Variance thresholds should be established in the planning phase and should be used to guide the examination of performance. Earned value project management is a well-known management system that integrates cost, schedule and technical performance. It allows the calculation of cost and schedule variances and performance indices and forecasts of project cost and schedule duration. The earned value method provides early

indications of project performance to highlight the need for eventual corrective action.

Name	Formula	Interpretation
Cost variance (CV)	$EV - AC$	NEGATIVE is over budget, POSITIVE is under budget.
Schedule Variance (SV)	$EV - PV$	NEGATIVE is behind schedule, POSITIVE is ahead of schedule.
Cost Performance Index (CPI)	EV / AC	Less than 1 poor performance Greater than 1 good performance.
Schedule Performance Index (SPI)	EV / PV	Less than 1 poor performance Greater than 1 good performance.
Estimate At Completion(EAC)	BAC / CPI $AC + ETC$	As of now, how much do we expect the total project to cost Rs _____. • Used if no variances from the BAC have occurred. • Actual plus a new estimate for remaining work. Used when original estimate was fundamentally flawed. • Actual to date plus remaining budget. Used when current variances are atypical. • Actual to date plus remaining budget modified by performance. When current variances are typical.
Estimate To Complete (ETC)	$EAC - AC$	How much more will the project cost?
Variance At Completion (VAC)	$BAC - EAC$	How much over budget will we be at the end of the project?

Table1.1: parameter of earned value analysis

1.3 DETAILS OF SOFTWARE:

Taking lead from the literature review the present study aims at evaluating Earned Value Analysis function of three software namely Microsoft Project 07, Primavera6 and Develop Software. The following sections explain the software in brief.

1.3.1 M.S. Project 07(MSP):

Microsoft Project (or MSP or WinProj) is a project management software program which is designed to assist project managers in developing plans, assigning resources to tasks, tracking progress, managing budgets and analyzing workloads. The application creates critical path schedules, and critical chain and event chain methodology with third-party add-ons. Cost Variance and Schedule Variance are visualized in a Report.

Microsoft Project is a project management software product, developed and sold by Microsoft. It is designed to assist a project manager in developing a plan, assigning resources to tasks, tracking progress, managing the budget, and analyzing workloads.

Microsoft Project was the company's third Microsoft Windows-based application, and within a couple of years of its introduction it became the dominant PC-based project management software.

It is part of the Microsoft Office family but has never been included in any of the Office suites. It is available currently in

two editions, Standard and Professional. Microsoft Project's proprietary file format is mpp.

Microsoft Project and Microsoft Project Server are the cornerstones of the Microsoft Office enterprise project management (EPM) product.

1.3.1.1 Features:

Project creates budgets based on assignment work and resource rates. As resources are assigned to tasks and assignment work estimated, the program calculates the cost, equal to the work times the rate, which rolls up to the task level and then to any summary tasks and finally to the project level. Resource definitions (people, equipment and materials) can be shared between projects using a shared resource pool. Each resource can have its own calendar, which defines what days and shifts a resource is available. Resource rates are used to calculate resource assignment costs which are rolled up and summarized at the resource level. Each resource can be assigned to multiple tasks in multiple plans and each task can be assigned multiple resources, and the application schedules task work based on the resource availability as defined in the resource calendars. All resources can be defined in label without limit. Therefore, it cannot determine how many finished products can be produced with a given amount of raw materials. This makes Microsoft Project unsuitable for solving problems of available materials constrained production. Additional software is necessary to manage a complex facility that produces physical goods.

The application creates critical path schedules, and critical chain and event chain methodology third-party add-ons also are available. Schedules can be resource leveled, and chains are visualized in a Gantt chart. Additionally, Microsoft Project can recognize different classes of users. These different classes of users can have differing access levels to projects, views, and other data. Custom objects such as calendars, views, tables, filters, and fields are stored in an enterprise global which is shared by all users.

A. Earned Value analysis Using M.S. Project

B. Primavera 6

Primavera 6 manages and controls activities related to project management as well as portfolio management. Resources representing labor, materials and equipment are used to track time and costs for the project. Slippages of projects' activities are updated resulting in the adjustment of time related bars. It requires Data Base of Oracle My SQL.

C. Developed Software

The Earned value analysis software developed in Visual studio 2008, SQL server and .NET (C#) language. And it provides robust project scheduling and management functionality. Features available are Planning, Scheduling, Cost Management and Project review.

1.4 Earned Value Analysis - EVA - Basics and Concepts:

According to Fleming (1996) EVA was originated in the DOD-Department of Defense - USA, from the former C/SCSC (Cost/Schedule Control Systems Criteria). The EVA technique is used in several countries, by great companies to get better cost and schedule control, with different names, such as: EVA - Earned Value Analysis, EVM - Earned Value Management, EVMS - Earned Value Management System and EVT - Earned Value Technique.

The main EVA variables (indicators) are:

- BCWS (Budgeted Cost of Work Scheduled) - PV (Planned Value)
- BCWP (Budgeted Cost of Work Performed) - EV (Earned Value)
- ACWP (Actual Cost of Work Performed) - AC (Actual Cost)
- SV (Schedule Variance) : $VP = EV - PV$; CV (Cost Variance): $VC = EV - AC$
- SPI (Schedule Performed Index): $SPI = EV / PV$; $SPI = 1$ (project on time)
- $SPI < 1$ (performing less than planned); $SPI > 1$ (performing more than planned)
- CPI (Cost Performed Index): $CPI = EV / AC$; $CPI = 1$ (project on budget)
- $CPI < 1$ (spending more than planned); $CPI > 1$ (spending less than planned)

EVA is now an American pattern (standard) - American National Standard Institute (ANSI) for electronic industry, through the standard ANSI-EIA-748-98, (American National Standards Institute/Electronic Industries Alliance - 1998 - Earned Value Management Systems). The use of EVA is guided by 35 criteria stated by DOD - Department of Defense - USA. According to DOD/5000-2R, the main EVA processes are: model definition, planning activities, resources and costs in an accounting plan, register of results for financial control, EVA Progress Report elaboration and monitoring/control with actions.

These processes are related with the Project Management (PM) processes (planning, execution and control) according to the Exhibit 1, provided by the Project Management

Institute - Practice Standard for Earned Value Management (2003):

EVA processes related with Project Management processes		
PLANNING	EXECUTION	CONTROL
Model Definition	Register of results for financial control	EVA Progress Report elaboration
Planning activities, resources and costs in an accounting plan		Monitoring and Control with actions

Exhibit 1 – EVA processes related with PM processes

These criteria are very important. They shall be read, studied and applied as key procedures to get success in EVA application.

2.1 THEORY OF EARNED VALUE ANALYSIS:

Earned Value Analysis (EVA) is an industry standard method of measuring a project's progress at any given point in time, forecasting its completion date and final cost, and analyzing variances in the schedule and budget as the project proceeds.

Earned value management (EVM), or earned value project/performance management (EVPM) is a project management technique for measuring project performance and progress in an objective manner.

Earned value management is a project management technique for measuring project performance and progress. It has the ability to combine measurements of the project management triangle: scope, time, and costs.

In a single integrated system, earned value management is able to provide accurate forecasts of project performance problems, which is an important contribution for project management.

Early EVM research showed that the areas of planning and control are significantly impacted by its use; and similarly, using the methodology improves both scope definition as well as the analysis of overall project performance. More recent research studies have shown that the principles of EVM are positive predictors of project success. Popularity of EVM has grown in recent years beyond government contracting, a sector in which its importance continues to rise (e.g. recent new DFARS rules, in part because EVM can also surface in and help substantiate contract disputes.

Essential features of any EVM implementation include:

- A project plan that identifies work to be accomplished
- A valuation of planned work, called planned value (PV) or budgeted cost of work scheduled (BCWS)

- Pre-defined "earning rules" (also called metrics) to quantify the accomplishment of work, called earned value (EV) or budgeted cost of work performed (BCWP)

EVM implementations for large or complex projects include many more features, such as indicators and forecasts of cost performance (over budget or under budget) and schedule performance (behind schedule or ahead of schedule). However, the most basic requirement of an EVM system is that it quantifies progress using PV and EV.

2.1.1 EARNED VALUE (EV):

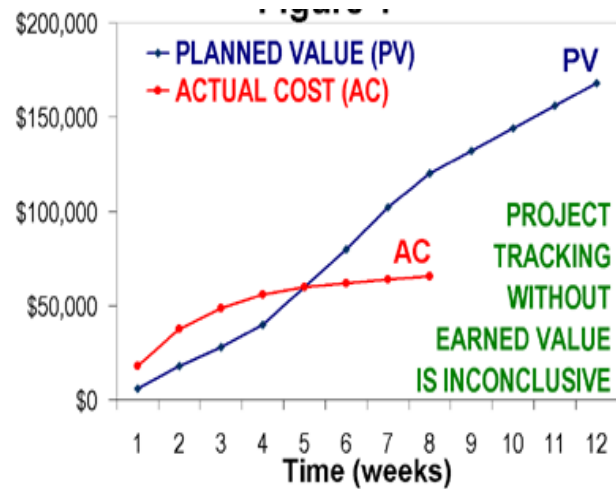


Fig 2.1

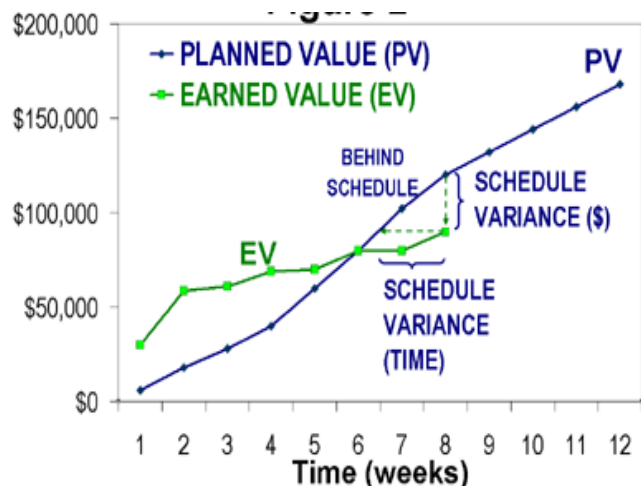


Fig 2.2

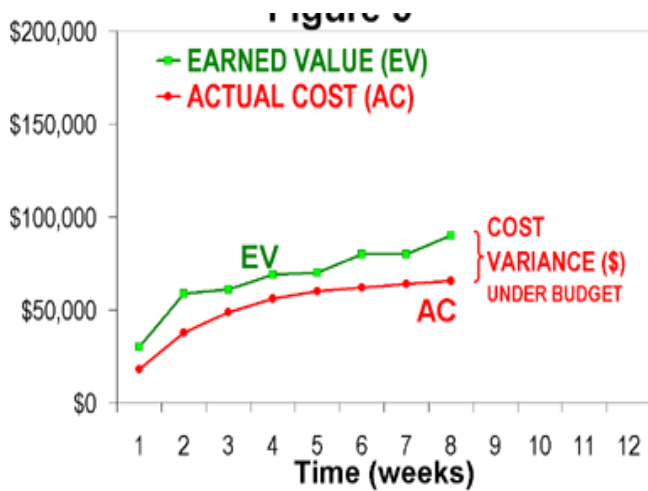


Fig 2.3

measuring technical performance objectively. This is the foundational principle of EVM.

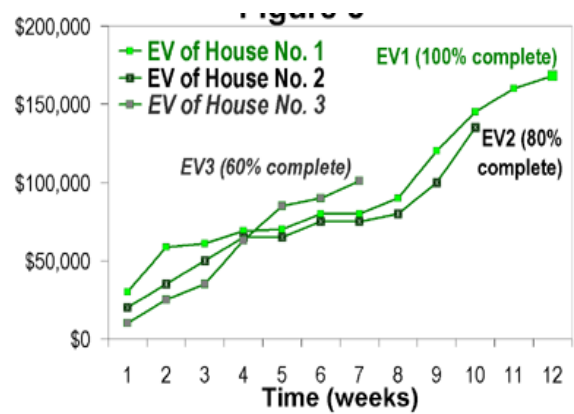


Fig 2.5

Figure 3.5. In this example, the progress of three residential construction projects are compared by aligning the starting dates. If these three home construction projects were measured with the same PV valuations, the *relative* schedule performance of the projects can be easily compared.

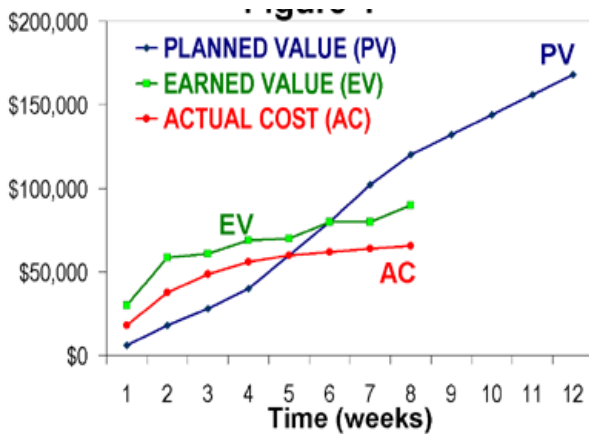


Fig 2.4

2.2 CPM:

The critical path method (CPM), or critical path analysis (CPA), is an algorithm for scheduling a set of project activities. It is commonly used in conjunction with the program evaluation and review technique (PERT).

2.2.1 Introduction

If you have been into project management, I'm sure you have already heard the term 'critical path method.'

If you are new to the subject, it is best to start with understanding the 'critical path' and then move on to the 'critical path method.'

Critical path is the sequential activities from start to the end of a project. Although many projects have only one critical path, some projects may have more than one critical paths depending on the flow logic used in the project.

If there is a delay in any of the activities under the critical path, there will be a delay of the project deliverables.

Most of the times, if such delay is occurred, project acceleration or re-sequencing is done in order to achieve the deadlines.

Critical path method is based on mathematical calculations and it is used for scheduling project activities. This method

Figure 3.2 shows the EV curve (in green) along with the PV curve from Figure 1. The chart indicates that technical performance (i.e. progress) started more rapidly than planned, but slowed significantly and fell behind schedule at week 7 and 8. This chart illustrates the schedule performance aspect of EVM. It is complementary to critical path or critical chain schedule management.

Figure 3.3 shows the same EV curve (green) with the actual cost data from Figure 1 (in red). It can be seen that the project was actually under budget, relative to the amount of work accomplished, since the start of the project. This is a much better conclusion than might be derived from Figure 1.

Figure 3.4 shows all three curves together – which is a typical EVM line chart. The best way to read these three-line charts is to identify the EV curve first, then compare it to PV (for schedule performance) and AC (for cost performance). It can be seen from this illustration that a true understanding of cost performance and schedule performance relies first on

was first introduced in 1950s as a joint venture between Remington Rand Corporation and DuPont Corporation.

The initial critical path method was used for managing plant maintenance projects. Although the original method was developed for construction work, this method can be used for any project where there are interdependent activities.

In the critical path method, the critical activities of a program or a project are identified. These are the activities that have a direct impact on the completion date of the project.

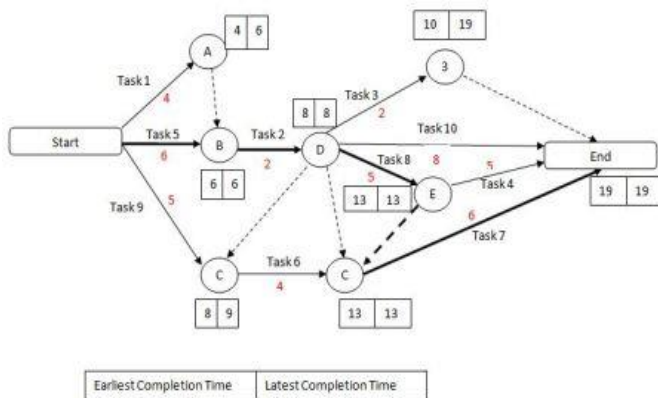


Fig 2.6: tree diagram for CPM method

2.2.2 Key Steps in Critical Path Method

Let's have a look at how critical path method is used in practice. The process of using critical path method in project planning phase has six steps.

Step 1: Activity specification

You can use the Work Breakdown Structure (WBS) to identify the activities involved in the project. This is the main input for the critical path method.

In activity specification, only the higher-level activities are selected for critical path method.

When detailed activities are used, the critical path method may become too complex to manage and maintain.

Step 2: Activity sequence establishment

In this step, the correct activity sequence is established. For that, you need to ask three questions for each task of your list.

- Which tasks should take place before this task happens.
- Which tasks should be completed at the same time as this task

- Which tasks should happen immediately after this task

Step 3: Network diagram

Once the activity sequence is correctly identified, the network diagram can be drawn (refer to the sample diagram above).

Although the early diagrams were drawn on paper, there are a number of computer software, such as Primavera, for this purpose nowadays.

Step 4: Estimates for each activity

This could be a direct input from the WBS based estimation sheet. Most of the companies use 3-point estimation method or COCOMO based (function points based) estimation methods for tasks estimation.

You can use such estimation information for this step of the process.

Step 5: Identification of the critical path

For this, you need to determine four parameters of each activity of the network.

- Earliest start time (ES) - The earliest time an activity can start once the previous dependent activities are over.
- Earliest finish time (EF) - ES + activity duration.
- Latest finish time (LF) - The latest time an activity can finish without delaying the project.
- Latest start time (LS) - LF - activity duration.

The float time for an activity is the time between the earliest (ES) and the latest (LS) start time or between the earliest (EF) and latest (LF) finish times.

During the float time, an activity can be delayed without delaying the project finish date.

The critical path is the longest path of the network diagram. The activities in the critical path have an effect on the deadline of the project. If an activity of this path is delayed, the project will be delayed.

In case if the project management needs to accelerate the project, the times for critical path activities should be reduced.

Step 6: Critical path diagram to show project progresses

Critical path diagram is a live artifact. Therefore, this diagram should be updated with actual values once the task is completed.

This gives more realistic figure for the deadline and the project management can know whether they are on track regarding the deliverables.

Advantages of Critical Path Method

Following are advantages of critical path methods:

- Offers a visual representation of the project activities.
- Presents the time to complete the tasks and the overall project.
- Tracking of critical activities

2.2.3 Conclusion

Critical path identification is required for any project-planning phase. This gives the project management the correct completion date of the overall project and the flexibility to float activities.

A critical path diagram should be constantly updated with actual information when the project progresses in order to refine the activity length/project duration predictions.

2.3 PERT:

The program (or project) evaluation and review technique, commonly abbreviated PERT, is a statistical tool, used in project management, which was designed to analyze and represent the tasks involved in completing a given project.

First developed by the United States Navy in the 1950s, it is commonly used in conjunction with the critical path method (CPM).

2.3.1 Introduction

Before any activity begins related to the work of a project, every project requires an advanced, accurate time estimate. Without an accurate estimate, no project can be completed within the budget and the target completion date.

Developing an estimate is a complex task. If the project is large and has many stakeholders, things can be more complex.

Therefore, there have been many initiatives to come up with different techniques for estimation phase of the project in order to make the estimation more accurate.

PERT (Program Evaluation and Review Technique) is one of the successful and proven methods among the many other techniques, such as, CPM, Function Point Counting, Top-Down Estimating, WAVE, etc.

PERT was initially created by the US Navy in the late 1950s. The pilot project was for developing Ballistic Missiles and there have been thousands of contractors involved.

After PERT methodology was employed for this project, it actually ended two years ahead of its initial schedule.

2.3.2 The PERT Basics

At the core, PERT is all about management probabilities. Therefore, PERT involves in many simple statistical methods as well.

Sometimes, people categorize and put PERT and CPM together. Although CPM (Critical Path Method) shares some characteristics with PERT, PERT has a different focus.

Same as most of other estimation techniques, PERT also breaks down the tasks into detailed activities.

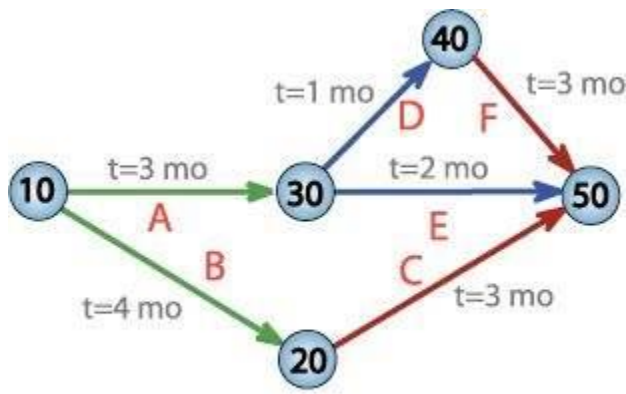
Then, a Gantt chart will be prepared illustrating the interdependencies among the activities. Then, a *network* of activities and their interdependencies are drawn in an illustrative manner.

In this map, a *node* represents each event. The activities are represented as arrows and they are drawn from one event to another, based on the sequence.

Next, the Earliest Time (TE) and the Latest Time (TL) are figured for each activity and identify the slack time for each activity.

When it comes to deriving the estimates, the PERT model takes a statistical route to do that. We will cover more on this in the next two sections.

Following is an example PERT chart:



PERT network chart for a seven-month project with five milestones (10 through 50) and six activities (A through F)

Fig 2.7: tree diagram for PERT method

2.3.3 The Three Chances

There are three estimation times involved in PERT; Optimistic Time Estimate (TOPT), Most Likely Time Estimate (TLIKELY), and Pessimistic Time Estimate (TPRESS).

In PERT, these three estimate times are derived for each activity. This way, a range of time is given for each activity with the most probable value, TLIKELY.

Following are further details on each estimate:

1. TOPT

This is the fastest time an activity can be completed. For this, the assumption is made that all the necessary resources are available and all predecessor activities are completed as planned.

2. TLIKELY

Most of the times, project managers are asked only to submit one estimate. In that case, this is the estimate that goes to the upper management.

3. TPRESS

This is the maximum time required to complete an activity. In this case, it is assumed that many things go wrong related to the activity. A lot of rework and resource unavailability are assumed when this estimation is derived.

2.3.4 The PERT Mathematics

BETA probability distribution is what works behind PERT. The expected completion time (E) is calculated as below:
 $E = (TOPT + 4 \times TLIKELY + TPRESS) / 6$

At the same time, the possible variance (V) of the estimate is calculated as below:

$$V = (TPRESS - TOPT)^2 / 6^2$$

Now, following is the process we follow with the two values:

- For every activity in the critical path, E and V are calculated.
- Then, the total of all Es are taken. This is the overall expected completion time for the project.
- Now, the corresponding V is added to each activity of the critical path. This is the variance for the entire project. This is done only for the activities in the critical path as only the critical path activities can accelerate or delay the project duration.
- Then, standard deviation of the project is calculated. This equals to the square root of the variance (V).
- Now, the normal probability distribution is used for calculating the project completion time with the desired probability.

2.3.5 Conclusions

The best thing about PERT is its ability to integrate the uncertainty in project times estimations into its methodology.

It also makes use of many assumption that can accelerate or delay the project progress. Using PERT, project managers can have an idea of the possible time variation for the deliveries and offer delivery dates to the client in a safer manner.

2.4 COST REDUCTION METHOD FOR CONSTRUCTION:

Time and cost are two main concerns which increase importance of cost reduction techniques. Reduction of cost of construction is a constant goal for construction industry. One way of reducing construction costs to develop innovative technologies as well as methodologies to increase productivity.

As a domestic or owner builder, you would know that your construction costs are hard to keep under budget. Construction costs including excavation, labour and equipment hire seem to have a habit of costing more than you are quoted for. Here are 5 simple things you can do to help reduce construction costs for your residential projects.

1. Apply the 80/20 rule

Also known as the Pareto Principle, the 80/20 rule is a very useful principle that can be applied not only to business but to your everyday life. The main concept behind Pareto's

Principle is that 80 per cent of outcomes comes from 20 per cent of inputs. When it comes to construction costs, we could say that 80 per cent of construction costs come from 20 per cent of your items/

If you are going to have any real effect on reducing construction costs, no matter what type of building you are constructing, look at those vital 20 per cent of items. Dependent on the build type this could be glazing, external wall, roof construction, concrete supply and placements, cabinetry or Prime Cost items. Make sure those items go out to a various number of tenderers and nail down the basic 80 per cent of your build cost to a fixed amount.

2. Control your variable costs

It's best to identify and be aware of your variable costs in your project before putting them out to the tendering process. Variable costs are those that varies over the project and include items such as labour hour rates, equipment hire (especially scaffolding) and excavation. This is opposed to fixed costs, which never change throughout the project.

To ensure you have your variables under control, check your allowances, run them over a time-line construction schedule and reduce the opportunity for them to explode. If anything is going to come and bite you in the ass, it will be your variable costs. Especially if there is no process for controlling these items in the first place. It's always best to consider fixed costs when possible when you are trying to reduce your construction costs.

3. Be wary of excavation costs

Excavation costs are regularly put out as a Provisional Sum meaning that you have only budgeted a set allowance for the works. Any more costs incurred past that set allowance is covered by the owner. But what if the owner runs out of money or flat out refuses to pay? VCAT tends to point the finger at the builder in this scenario, as it was the builder who provided the provisional sum in the first place.

The best way around this is to prepare for the unexpected. Have your client pay for some preliminary costs which include soil tests and surveying. If the reports produce any outstanding results, you can be sure to allow a higher provisional sum for excavation costs to avoid any pitfalls during your construction project.

4. Consider alternative products

Your supplier might be your best friend, but how do you know he is giving you the best deal? There may be alternatives to the products you are used to building with

that are more cost effective. For instance, have you considered comparing the costs of stick frames and labour against prefabricated frames? Although the costs for prefabricated frames are more expensive, you tend to save on discounted labour. You could also compare the differences between metal roofing and concrete tiles. Metal roofing involves less trusses, less maintenance and less load.

Be aware of any alternative methods to building you could benefit from to reduce your construction costs. Just make sure you get a quote beforehand and compare what products suit your project.

5. Create a project plan

The most effective way to managing cost spending is managing a project plan. There are hundreds of ways you can create a Project Plan whether it be in your site diary or using software such as Microsoft Excel or Project. While there is a bit of extra work involved, you may find that laying out the entire project visually may help you identify any problems before they arise.

Now that you are aware of what to look for – the next step is to take action. Just remember to gather and compare quotes and be open to alternative methods there are to what you are used to. Also be aware to keep an eye on variable costs from spiraling out of control. There are many ways you can reduce your construction costs and they are mainly made from precise planning and forward thinking.

3.1 CASE STUDY

AAMBY VALLEY NORTH LAKE



Fig 3.1

SITE DETAILS

- Name of site : Aamby Valley North Lake
- Location of site: -North Lake, Aamby Valley, Lonavala, Pune.

- Site Engineer: Emtiyaz Ahemad
- Consultant : Green Design
- Proposed telecom tower having one Tower is taken for case study location is in Lonavala, Pune.
- Owner and Developer: ATC Telecom Tower Corporation Pvt. Ltd.
- Cost of project : 5,27,579.05
- Area: 11 m²
- Telecom tower having No. of Towers: 1
- Present condition of the project : Completed



Fig 3.4



Fig 3.2

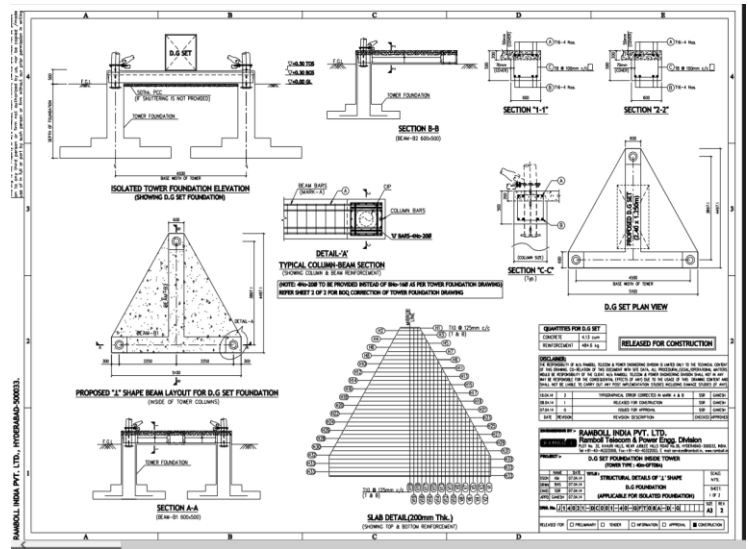


Fig 3.5: foundation detailing



Fig 3.3

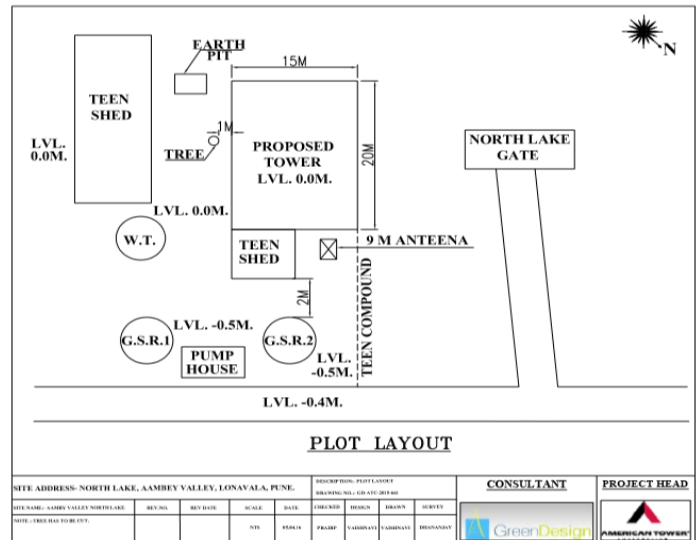


Fig 3.6: plot layout



Fig 3.7



Fig 3.10



Fig 3.8



Fig 3.11



Fig 3.9