Earned Value Analysis In Residential Building

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Abstract- *This paper provides the reader insight into the full value that can be gained when Earned Value is deployed to report project performance. A four-phase framework is offered as a lens through which to apply and interpret earned value data in a meaningful and informative manner. The paper briefly discusses the origins of Earned Value, the purpose and over of the key formulae, and then discusses the four-phase framework: 1) identify what's important, 2) create a reporting schedule, 3) create actionable results, and 4) create a culture of accountability through reporting. Finally, some of the primary limitations of earned value are surveyed.*

Keywords- earned value, analysis, etc

I. INTRODUCTION

Earned Value Analysis (EVA) is one of the key tools and techniques used in Project Management, to have an understanding of how the project is progressing. EVA implies gauging the progress based on earnings or money. Both, schedule and cost are calculated on the basis of EVA.

1.1.1 Features of EVA

- Earned Value Analysis is an objective method to measure project performance in terms of scope, time and cost.
- EVA metrics are used to measure project health and project performance.
- Earned Value Analysis is a quantitative technique for assessing progress as the software project team moves through the work tasks, allocated to the Project Schedule.
- EVA provides a common value scale for every project task.
- Total hours to complete the project are estimated and every task is given an Earned Value, based on its estimated (%) of the total.
- Earned Value is a measure of 'Progress' to assess 'Percentage of Completeness'

1.1.2Need for EVA

- EVA provides different measures of progress for different types of tasks. It is the single way for measuring everything in a project.
- Provides an 'Early Warning' signal for prompt corrective action. The types of signals can be the following:

a) **Bad news does not age well –** Holding on to the bad news does not help. The project manager needs to take an immediate action.

b) **Still time to recover –** In case, the project is not going as per schedule and may get delayed, the situation is needed to be taken care of by finding out the reasons that are causing delay and taking the required corrective action.

c) **Timely request for additional funds –** While there is time to recover, the need for additional resources or funds can be escalated with an early warning.

- It allows 'rolling up' the progress of many tasks into an overall project status.
- It provides with a uniform unit of measure (dollars or work-hours) for the progress.

1.1.3 Key Elements of EVA

- **Planned Value (PV)** – The approved cost baseline for the work package. It was earlier known as Budgeted Cost of Work Scheduled (BCWS).
- **Earned Value (EV)** – The budgeted value of the completed work packages. It used to be known as Budgeted Cost of Work Performance at a specified point (BCWP).
- **Actual Cost (AC)** – The actual cost incurred during the execution of work packages up to a specified point in time. It was previously called Actual Cost of Work Performed (ACWP).

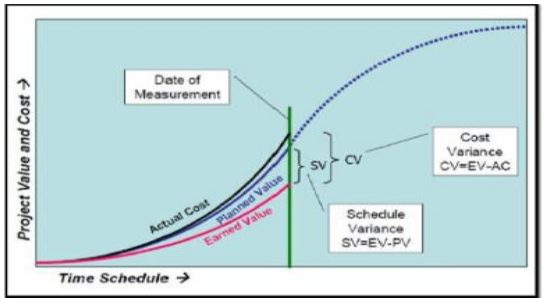

Fig 1: Standard Earned Value Analysis Graph

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. 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.

Table1.1: Parameter Of Earned Value Analysis

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?

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.

A. M.S. Project

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.

FeaturesOf MSP:

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.

B. Primavera 6

Primavera 6 manages and controls activities related to project management as well as portfolio management. Resources representing labour, 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 Defence – 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

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.

1.5 Aim of study

To perform earned value analysis for residential and commercial building for better project tracking

1.6 Objective of study

- To study earned value analysis and its implementation in construction industry.
- To identify cases for cost overrun in all construction activities.
- To reschedule activities to lower or increase cost performance index and schedule performance index of project to avoid cost overrun
- To perform S curve analysis in given case studies

1.7 Methodology

The project work will be carried out in phases mentioned below :

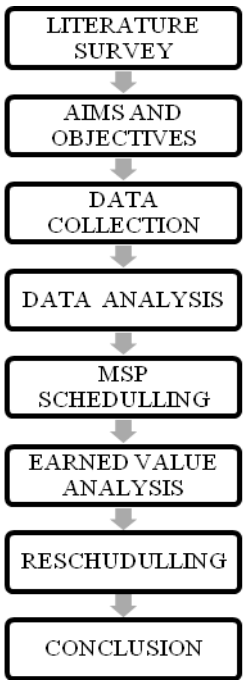

Fig. No. 2: Methodology Flow Chart

II. THEORETICAL CONTENT

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 DFARSrules, 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):

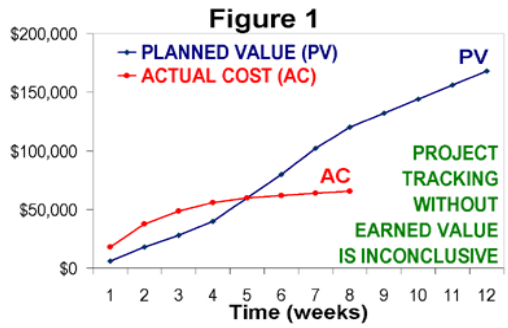

Fig. 3

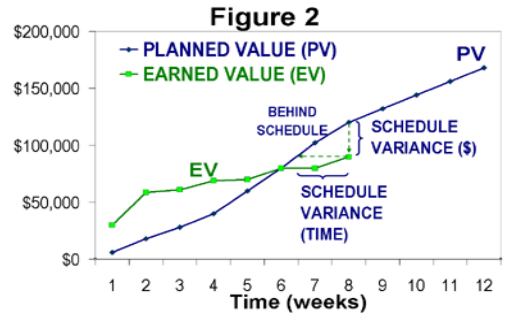

Fig 4

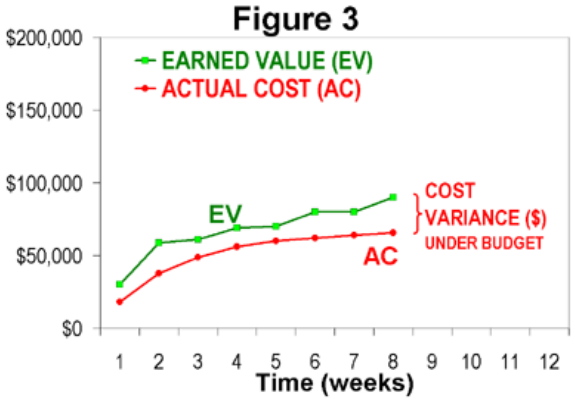

Fig 5

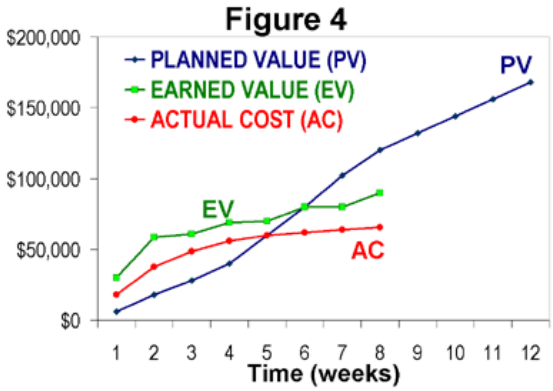

Fig 6

Figure 4 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 5 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 6 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 measuring technical performance objectively. This is the foundational principle of EVM.

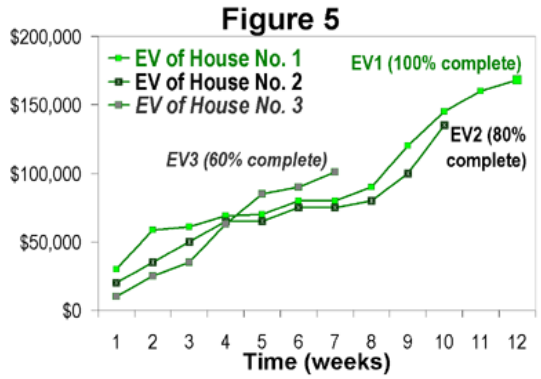

Fig 7

Figure 7. 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.

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 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.

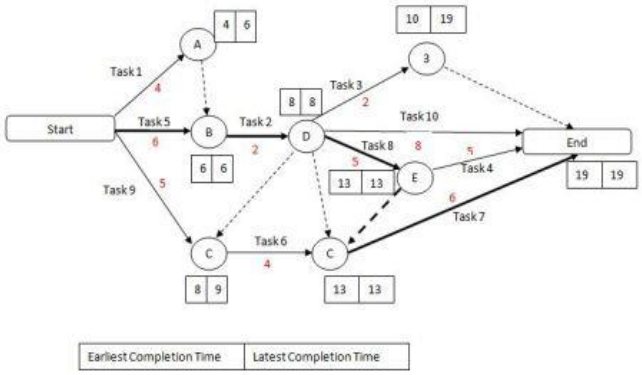

Fig 8: Tree Diagram ForCPM Method

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

2.2.2 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 Conclusion

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 cost 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, labor 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.

III. CASE STUDY

SITE DETAILS

- Name of site : Cool homes

Fig 9: 3rd eye view of actual site

- Location of site : cool homes, ring road, behind gajananmaharajmandir, bhusawal, jalgaon.
- A G+4 proposed building of 24 flats and of 4 shops is taken for case study location isinBhusawal.
- Design Team : Apex consultant
- Owner and Developer :ShivajiPatil
- Architect :SnehaNichat
- Cost of project: 2.4 cr.
- Structural Engineer :NavneetPatil and PrashantPatil
- Builder: Praj Infra Solutions pvt.ltd.
- Area : 6400 sq.feet
- Residential building having 24 flats and 4 commercial road front shops.
- This project is based on sustainable structure
- Present condition of the project : Excavation is done, now working on centrelining of foundation.
- This project using heat resisting theme building project. (In bhusawal the temperature in summer risesupto 48-49 degree celc.
- Total 24 flats and 4 shops.
    i. 16 flats – 2bhk
    ii. 8 flats – 1 bhk
    iii. 4 shops – commercial road front shops.

Cool Homes

Luxurious New technology cool homes

Every Family is in search of perfect home for their perfect family, to bring your search to end Praj infra solution pvt ltd presents you Cool Homes,

Cool homes is new Technologically advanced Flats scheme to give your family perfect cozyhome in those hot worm days(as per suistainable building standards).

In your Cool home bellow technologies will be used to give your family perfect cozy home which will be Cool from inside in those hot worm days

Details And Features Of Building

New Technological AAC Bricks which has low thermal conductivity and Heat Insulated

1. Thermally Insulated & Energy Efficient

- Tiny air pores and thermal mass of blocks provide excellent thermal insulation, thus reducing heating and air conditioning costs of a building.

2. Fire Resistant

- Non-combustible and fire resistant up to 1600° C.
- Can withstand up to 6 hours of direct exposure.

3. Cool Roof Technology –

A cool roof is a roofing system that delivers higher solar reflectance (the ability to reflect the visible, infrared and ultraviolet wavelengths of the sun, reducing heat inside your home

4. UV Protected Windows-

UV window films cut out 99% of UV rays and 79% of solar Energy and allow only Visible light to enter inside your Dream home reducing heat inside.

5. Admixture And Exterior Paints –

Special Type of Admixtures in plaster and Paints in exterior size to Resist heat and Keep your Dream home cool

IV. DATA COLLECTION

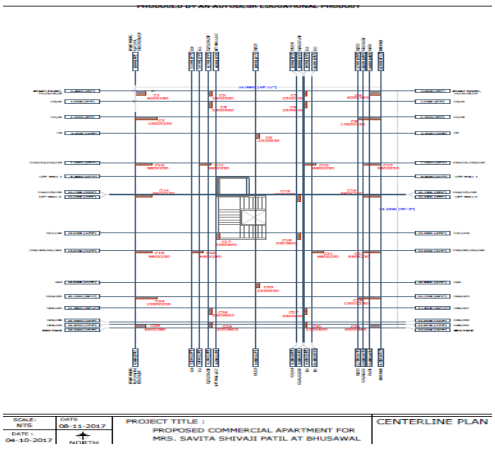

Fig NO.10: Setting Out Plan

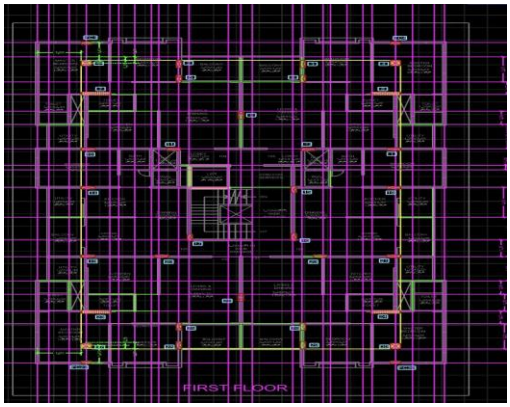

Fig no. 11: Centre Line Plan

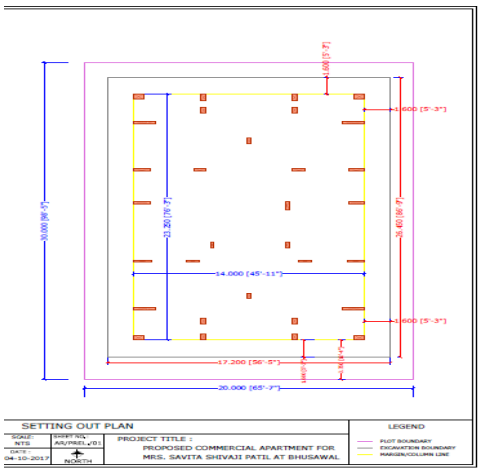

Fig 12: First Floor Centre Line Plan

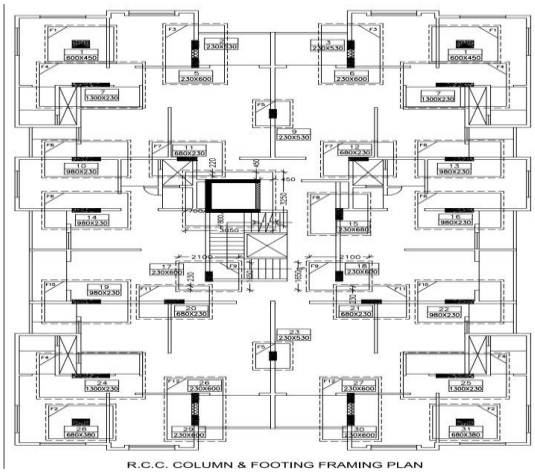

Fig 13: R.C.C. COLUMN & FOOTING FRAMING PLAN

V. CONCLUSION

The main conclusion is that EVA provides a relevant contribution to the cost management in construction projects, namely in the case COOL HOMES Project. EVA contributed to cost management in Monica Park Project and the use of EVA in Monica Park Project contributed also to the application of EVA in construction projects, in general, and in the future, through the data, perceptions and concerns developed in this paper.

Some considerations were added to the ones found in the main EVA book references. For changing the scope of a project it gets very complex by using EVM. This was very clear in the use of EVA in Monica Park. One insight that reduced problems was that the reports allow easy and fast fixing of mistakes. Not only mistakes on digitizing numbers, but mistakes in the expectations related to the measuring criteria. The record and reporting method offer easy regularity analysis of data. Wrong data was easily identified and fixed. Error recognition allowed improved practices and provided support for the decision making process, as well as discussions with suppliers and 3rd parties

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