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PLANNING, SCHEDULING AND EARNED VALUE MANAGEMENT ANALYSIS OF GREEN CONSTRUCTION

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ABSTRACT

Indian construction industry is the second largest sector after agriculture. Construction Industry these days are going under reformation, where paradigm is shifting towards Green Construction. This type construction is eco-friendly and sustainable. In light to any type of construction, the heart and soul of any project is it proper planning and project management, where we can keep record of duration, resources, cost and other parameters.In the current paper, an existing conventional building is transformed into green building by replacement of some of its element with green ones, so as to call it as Green project. Detail Estimate and BOQ is extracted so as to plan and schedule the building in Primavera P6. EVM analysis is performed on it to get EVM indicators such as EV, PV, SPI, SV, CV and CPI.Apart from the green project, existing/conventional project is also scheduled in Primavera P6 and EVM analysis is performed on it. So that results of both Projects can be compared and concluded.

KEYWORDS:

Earned Value Management;
Planning;
Scheduling;
Primavera P6;
Green Building.

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1. INTRODUCTION

A 'green' building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life.[1]

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Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

Planning, scheduling is an important part of the construction management. Planning and scheduling of construction activities helps engineers to complete the project in time and within the budget. The term 'Construction' does not only denote physical activities involving men, materials and machinery but also covers the entire gamut of activities from conception to realization of a construction project. Thus, management of resources such as men, materials, machinery requires effective planning and scheduling of each activity.

Earned Value Management (EVM) is a method that allows the project manager to measure the amount of work actually performed on a project beyond the basic review of cost and schedule reports[3].EVM provides a method that permits the project to be measured by progress achieved. The project manager is then able, using the progress measured, to forecast a project's total cost and date of completion, based on trend analysis or application of the project's "burn rate". This method relies on a key measure known as the project's earned value.

EVM indicators are in table 1:

NAME	FORMULA	INTERPRETATION
Planned Value (PV) or Budgeted Cost for Work Scheduled (BCWS)		
Earned Value (EV) or Budgeted Cost for Work Performed		
Cost Variance (CV)	CV=EV-AC	-ve = Over Budget, +ve = Under Budget
Schedule Variance (SV)	SV=EV-PV	-ve = Behind Schedule, +ve = Ahead Schedule
Schedule Performance Index (SPI)	SPI=EV/PV	SPI=1 means Project is on schedule SPI<1 means Project is Behind schedule SPI>1 means Project is Ahead schedule
Estimate AtCompletion (EAC)	EAC=AC+(BAC-BCWP)/CPI	As of now how much do we expect total project cost
Estimate to Completion (ETC)	ETC=EAC-AC	How more to finish
Variance at Completion (VAC)	VAC=BAC-EAC	How much over/under we expect to be

Table 1. EVM Indicator[2]

2. METHODOLOGY

2.1. Selection of Green Project:

Green Project is design by considering a conventional building and replacing it elements to green ones, so as to consider the building green.
Following are changes made in green building:

Element of Conventional building (which are replaced)	Green Elements
Concrete blocks	Flys ash block
Normal paint	Low VOC Paint
Normal Lighting Fixtures	LED lighting Fixtures
Normal Faucets	Low water Faucets

Table 2. Green elements replaced

Following are site statistics:

Sl.no	Particular	Specification
1	Site area	**3117.9 m^2**
2	Area/flat	**117.308 m^2**
3	No. of floor	**LB+UB+G+20**
4	Coverage	**2752 m^2**

Table 3. Site Statistics

Further in design of Green Buildin, it includes Open to Slab(OTS) so as to increase ventellation and natural lighting in the building.

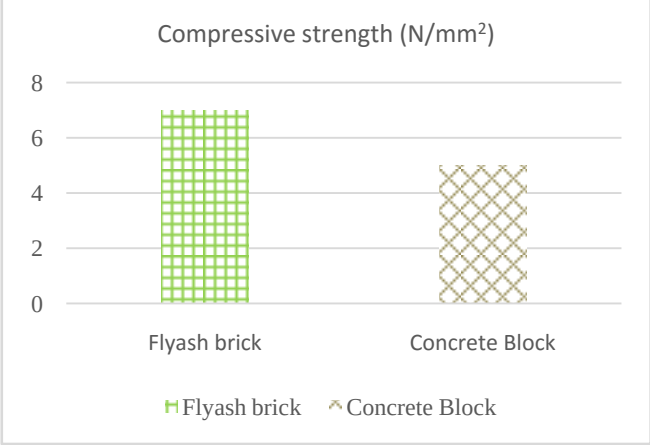

Figure 1. *Comparison between Flyash brick and Concrete block [7]*

2.2. Estimation and bill of Quantities:

Before planning of any project, we must BOQ prepared for the project so as to know the cost of the project. So, estimation of Quantities are extracted on MS Excel using design plan of the building. In this scenario Drawing plan will be same for both project so

quantities the projects extracted will be same. Since we are changing the elemets of the projects the BOQ build using the estimate quantities will differ from each other.

Project Type	Budgeted Cost	Duration (days)
Green Building	Rs.36,36,80,492	856
Conventional Building	Rs.36,40,79,548	856

Table 4. *Cost of prjects*

2.3. Prepare Plan and schedule using Primavera*:*

Primavera P6 is used as planning software here, where it uses to perform schedule and attain EVM parameters.

The following are step to schedule a project[3]:

i. Create Project:New project is created in the Primavera P6 , by defining EPS and OBS. And start date is defining

ii. Define WBS:WBS for the project is created, by providing sequential work of the project, in the main categories. While defining WBS it should be kept in mind that hierarchy of the WBS should relate with BOQ.

iii. Calendar

Calendar is set as according to the standard of work of the company, usually includes regional work schedule and holidays

iv. Defining Activities:In Primavera Activities are created according to BOQ items extracted,. These activities are distributed through Whole WBS in some logical sequence. Activities are logical relationship, duration and lags.

v. Performing Scheduling: Basically, in primavera Schedule is done on the principles of CPM , where schedule is done base on activity links , which in part create a critical part.

Schedule can be done for any required date.

vi. Resource allocation: Resource list is created according to BOQs , and resources are distributed are distributed according among the activities.

Resources plays important role while scheduling; the cost of the project depends on resources.Cost of resources are extracted from the BOQ. In BOQ each item cost is distributed among its Activity ID, so it would be helpful during resource allocation [9].

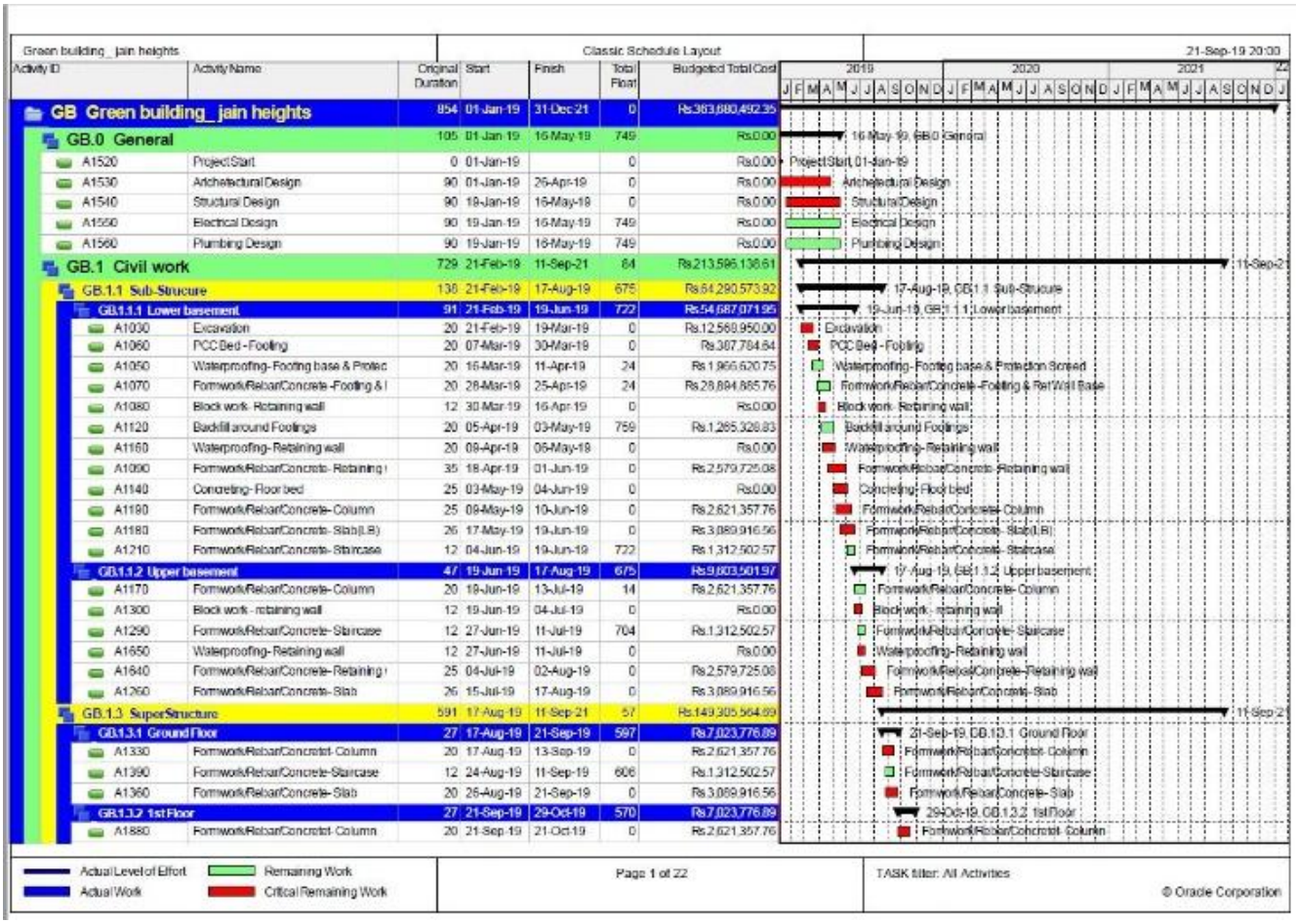

Figure 2. *Sample fo scheduling in Primavera P6*

2.4. EVM Analysis*:*

The steps involve after scheduling leads to performance of earned value analysis as follows [10]:

i. Creating basline of the project by selecting same project or different project as base line.

ii. Updating/tracking the project by giving inputs of its progress.

Creating the baseline is the crucial step to perform EVM analysis, to that baseline is assign to the project. And the project is track by updating the activity progress, start date and finish date. After the updation of project we arrive at EVM parameter.

2.5. EVM parameters comparison:

EVM parameters for both project at the date of completion are:

Project	Earn value	Planned Value	SPI	SV
Green building	Rs.10,71,21,217	Rs.129332939	0.83	(Rs.2,22,11,722)
Conventional Building	Rs.10,71,78,225	Rs.129421083	0.82	(Rs.2,22,42,857)

Table 5. EVM parameters

Earned value and Planned value for updated dates of Conventional Building are shown in table 6 and S-curve for it is shown in figure 3.

NO	Date	PV	EV
1	Jan-19	₹ 0.00	₹ 0.00
2	Feb-19	₹ 38,96,374.50	₹ 38,96,374.50
3	Mar-19	₹ 1,73,34,810.73	₹ 1,65,46,175.88
4	Apr-19	₹ 4,57,76,285.13	₹ 4,33,93,094.34
5	May-19	₹ 5,10,22,161.56	₹ 4,95,79,479.08
6	Jun-19	₹ 5,61,46,719.96	₹ 5,49,32,824.24
7	Jul-19	₹ 6,26,58,080.58	₹ 6,26,34,378.64
8	Aug-19	₹ 6,75,88,346.04	₹ 6,62,37,202.89
9	Sep-19	₹ 7,54,96,752.24	₹ 7,14,49,472.34
10	Oct-19	₹ 8,51,45,206.48	₹ 7,81,01,760.29
11	Nov-19	₹ 9,31,81,978.21	₹ 8,45,68,234.19
12	Dec-19	₹ 10,36,10,078.61	₹ 9,08,12,626.26
13	Jan-20	₹ 11,48,21,963.92	₹ 9,83,96,392.16
14	Feb-20	₹ 12,49,86,006.64	₹ 10,51,44,271.57
15	Mar-20	₹ 13,62,97,291.05	₹ 10,71,78,225.02

Table 6. EV and PV for conventional building

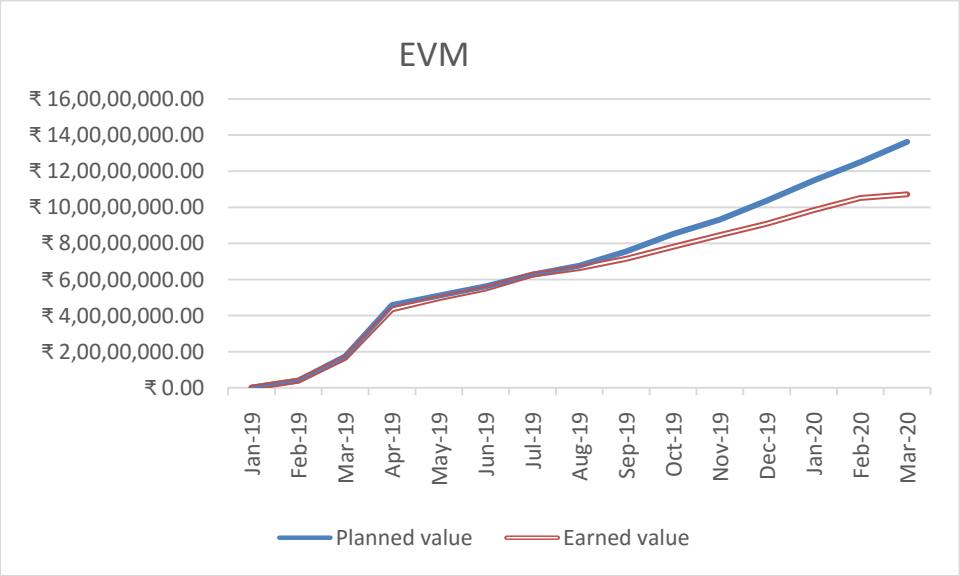

Figure 3.*S-curve for Conventional building*

Earned value and Planned value for updated dates of Green Building are shown in table 7and S-curve for it is shown in figure 4.

NO	Date	PV	EV
1	Jan-19	₹ 0.00	₹ 0.00
2	Feb-19	₹ 38,96,374.50	₹ 38,96,374.50
3	Mar-19	₹ 1,73,34,810.73	₹ 1,65,46,175.88
4	Apr-19	₹ 4,57,76,285.13	₹ 4,33,64,801.84
5	May-19	₹ 5,10,22,161.56	₹ 4,95,79,479.08
6	Jun-19	₹ 5,61,46,719.96	₹ 5,49,22,994.15
7	Jul-19	₹ 6,26,58,080.58	₹ 6,26,34,378.64
8	Aug-19	₹ 6,75,88,346.04	₹ 6,60,97,903.37
9	Sep-19	₹ 7,54,96,752.24	₹ 7,14,49,472.34
10	Oct-19	₹ 8,51,32,343.14	₹ 7,80,85,365.84
11	Nov-19	₹ 9,31,53,035.70	₹ 8,45,36,563.09
12	Dec-19	₹ 10,35,64,179.87	₹ 9,08,00,778.62
13	Jan-20	₹ 11,47,58,378.10	₹ 9,83,39,384.18
14	Feb-20	₹ 12,49,06,341.64	₹ 10,58,76,667.31
15	Mar-20	₹ 13,61,99,938.96	₹ 10,71,21,217.04

Table 7. EV and PV for Green building

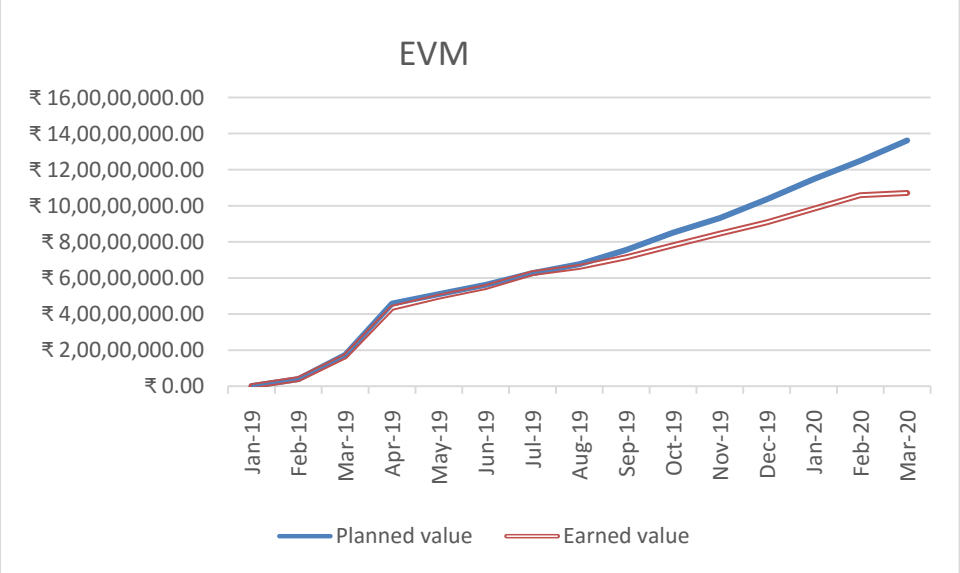

Figure 4.*S-curve for Green building*

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3. RESULTS ANDDISCUSSION

- Since analysis SPI of green project is 0.83 and conventional project is 0.82
- Schedule variance of both project are in negative value
- By comparing the cost of the projects there is difference of around 4 lakh rupees which is not a major difference in case of 36 crore projects

Project Type	Budgeted Cost	Duration (days)
Green Building	Rs.36,36,80,492	856
Conventional Building	Rs.36,40,79,548	856

Table8: Cost and duration comparison of both project

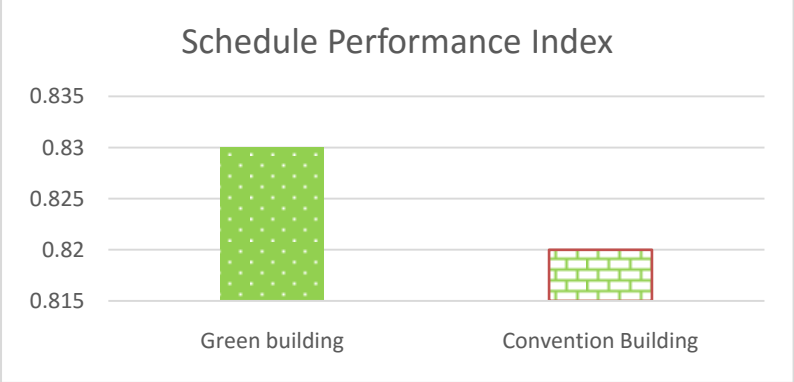

Figure 5. Schedule Performance Index

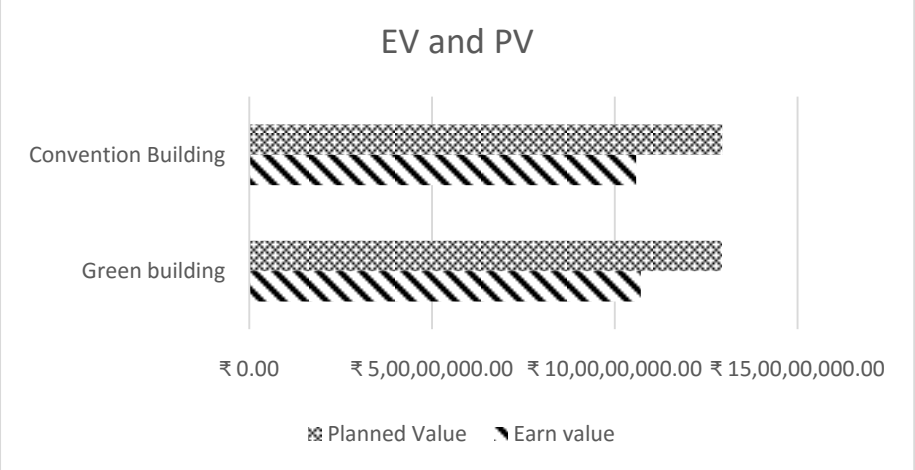

Figure 6. Earned value and Planned Value

4. CONCLUSION

Green project with above mention features can cost only around 4 lakh Indian rupees less. Moreover, green materials make the building more sustainable and economical in their life time. EVM indicators analysed shows that green project is 17% behind the schedule as compare to conventional project that is 18% behind the schedule. And cost run out faster in case of conventional project.

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