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A Relative Study on CCPM And LOB Scheduling Technique

KEYWORDS: CCPM, LOB, Construction Management, contractor, client, Earned value

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ABSTRACT *The emphasis on the modern day project management is on the spot light these days. After the success of Critical chain project management (CCPM) technique in the manufacturing industry, it's now getting into the construction domain. Being a resource based scheduling technique it's more a contractor oriented. Line of balance (LOB), a resource based scheduling technique developed in the early 1940s is also getting enriched outputs with the various construction activities whenever implemented. The study focuses on the after effects of implementation of CCPM and LOB from the client. The paper tries to bring financial progress in the spotlight.*

1. INTRODUCTION

Now a days construction projects have become more complex and unique. A proper Planning and monitoring both financially and physically is ground zero for completion. As construction project management is further advanced, the adoption of new management principles is top priority. The paper focuses on comparison of the above said scheduling techniques and their effect on execution and variation in Earned Value.

CCPM has emerged in the last few years as a novel approach for managing projects. Analysis on the principles, assumptions and techniques of CCPM in the light of their contribution to project management practice and to project success is emphasized. The continued critical analysis of CCPM in the light of the evidence in the research literature and in practice. The points addressed include duration estimation practices; project network structure; stability of the critical chain; resource productivity under multitasking; and the organizational and operational environment of the project. We also consider the place that CCPM occupies in the broader project management context, and the costs associated with its adoption. Our conclusion is that although CCPM has a number of valuable concepts, it does not provide a complete solution to the needs of project management. Consequently, organizations should be very careful when considering the adoption of CCPM to the exclusion of conventional project management techniques and methods (Tzvi Raz, Robert Barnes and Dov Dvir., 2001).

The Goodyear Company founded the LOB technique in the 1940's and it was then developed by the US Navy in the 1950's. Since then Line of Balance techniques have taken a back seat and have never been commercialized due to the explosion of systems based on Network Analysis and CPM. It should be said that these network and CPM systems have never actually replaced the LOB method; their popularity has simply been due to the unavailability of commercially accessible LOB software. A modified form of the LOB method has been the dominant scheduling technique in Finland since the 1980s.

The LOB technique for planning and scheduling repetitive projects such as high rise buildings, row housing, precast concrete production, etc., has been used since the 1950s. It has provided unique and useful dimensions to users in perceiving when a project goes out of balance in addition to its essence of capitalizing on the economy of repetition. However, it is still not suitable enough for dealing with repetitive projects where the network of the typical unit is complex and has many branching paths. It is unwieldy in large projects, difficult to update or accelerate, and does not immediately give an accurate measure of the time progress of a project.

The critical path method (CPM), on the other hand, is developed to an extent that it predominates in the industry. However, its use on repetitive projects is challenged by its inability to react promptly to the incident problem of changing the sequence of work on the typical units and to maintain work continuity for the working squads. The virtue of the method lies in its invulnerability to changes in the sequence of work and to its ability to maintain work continuity for the working squads of the repetitive activities.

2. METHODOLOGY

The research starts with the implementation of the CCPM and LOB on a trail run basis for villas project (G+ 2 framed structures). However, for this time bound project the total duration for handover of the structure work was considered initially as 11 months. Activities are the fundamental work elements of a project. They are the lowest level of a work breakdown structure (WBS) and, as such, are the smallest subdivision of a project that directly concerns the module. Resources include the personnel and equipment that perform work on activities across all projects. Labour and non-labour resources, such as engineers and equipment, are always time-based and are usually assigned to other activities and/or projects; material resources, such as supplies and other consumable items, are recorded in terms of cost per unit, rather than hours.

After the duration was fixed a detailed schedule with WBS was drawn right from layout marking to external plastering by using CPM technique. This schedule was taken as benchmark for the sequencing of other schedule i.e., CCPM and LOB. The resources for each activity were calculated using the basic relation:

All the relevant cost data are according to the Delhi Schedule of Rates (DSR) - 2012 released by the Central Public Works Department, New Delhi. After the schedules with different techniques were finalized the following durations were derived from the schedule with respect to the scheduling technique:

Sl. No	Scheduling Technique	Baseline Duration
1	CPM	336 days
2	CCPM	246 days
3	LOB	306 days

Table 1: Baseline duration corresponding to scheduling technique

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Once a project is underway, it is important to keep the schedule up to date. Actual durations will probably vary from your original estimates. Regularly updating schedules and comparing them with baseline schedules ensures that you are using resources effectively, monitoring project costs against budget, and keeping abreast of actual durations and costs so you can initiate your contingency plan if necessary. A baseline is a complete copy of a project plan that you can compare to the current schedule to evaluate progress. Baselines needs to be managed which can be used to compare with the current schedule to gauge progress followed by updating and levelling.

After the finalization of the baseline schedule, the tracking of progress was started. The construction sequence of the two different villa projects was tracked with the two different schedules viz., CCPM and LOB. The schedule was updated every fortnight and consequently earned value (EV) was carried to track the financial progress v/s planned. EV emulates the project performance. Here an attempt was made to carry out analysis from client end and contractor end. Totally four schedules are drawn i.e., two for contractor (CCPM & LOB) and two for client (CCPM & LOB).

As a client the budget for the project will be fixed. The BOQ specifies the quantity and the amount to be paid by the client to the contractor after the execution. The work is completed today or tomorrow the amount to be paid by the client will be fixed, however the liquated damages in the contract document will take care of the delay caused by the contractor. Conversely, the same doesn't reflect with the contractor. If there is a delay, the contractor's direct cost and indirect cost shoots up which will obviously drop his profit margin. So most contractors prefer resource based planning which is realistic rather than planning with time.

Resource based planning provided a good insight about the project as the forecasting of resources is directly proportional to the progress and vice versa. Once the required resources are on board, re-allocation of resources becomes easy when there is a delay or when a catch up schedule is drawn by crashing of activities. Resource planning is very important as it's directly proportional to the physical and financial progress of the project. The following tables give list of differences between LOB and CCPM technique:

Sl.No	LOB	CCPM
1	Resource allocation is not given much emphasis.	Resource allocation is ground zero for implementation.
2	Activities with same resources are identified and later the schedule is framed.	Activities with same resources are identified and the start-finish dates are altered within the available float.
3	Graphical representation is a highlight here.	Only traditional method of using the schedule and Gantt chart for tracking.
4	Individual activities are secured by safety time.	Overall project is secured by feeding buffer and project buffer.
5	Actitity start and finish date is subjective to scheduled start and finish.	Starts and finishes the tasks as soon as possible.
6	Retorts to uncertainty by altering precedence, accelerating, and creating a new schedule.	Manages uncertainty by monitoring influence of actions on buffer ingesting.

Table 1: Variances between LOB and CCPM

3. RESULTS

The CCPM and LOB scheduling technique was implemented on a villa project on a trail run basis. Various reports were generated after the schedule was freezed. All the relevant cost data are according to the Delhi Schedule of Rates (DSR) - 2012 released by the Central Public Works Department, New Delhi (http://cpwd.gov.in/DSR2012.pdf). The main report spawned every fortnight was earned value report to track the financial progress with respect to planned. The earned value graph was also drawn at the end of the project to know the cost variance.

3.1CCPM RESULTS

Figure 1 shows the earned value report for the client under CCPM technique. The client graph shows no variation at the end of the project because the client cost is fixed for the execution and the only variation we can expect is the inflation on class A materials. The actual cost and the earned value are almost same due the same reason of cost being fixed for the client. The planned value looks slightly higher during the Q3 of 2012 which implies over budgeting.

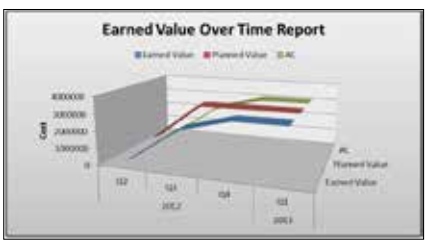

Figure 1: Earned Value Report- (Technique: CCPM; Approach: Client)
(Refer Annexure-1 for the values used to generate the graph)

Figure 2 shows the earned value generated for the contractor under the CCPM method. The figure explains how the actual cost and earned value has gone up phenomenally versus planned due to the delay in execution. The planned value is lower than the earned value and actual cost which signifies under budgeting by the contractor. Delay in execution results in cost overrun which is indicated in the graph.

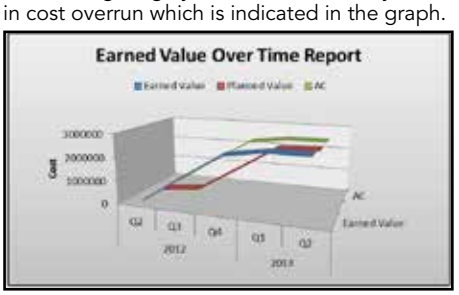

Figure 2: Earned Value Report- (Technique: CCPM; Approach: Contractor)
(Refer Annexure-2 for the values used to generate the graph)

3.2LOB RESULTS

Figure 3 shows the earned value generated for the client under the LOB method. The graph exhibits a clear S-curve. But the planned value is higher than the earned value which indicates the project was over budgeted. The client engineers felt that LOB was a comfortable scheduling technique to track and monitor the progress at the site. For any client the cost for construction is fixed and the only varying factor is inflation which will affect the client supply materials.

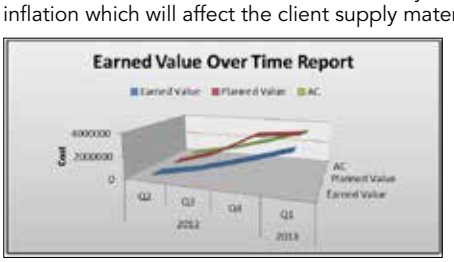

Figure 3: Earned Value Report- (Technique: LOB; Approach: Client)

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(Refer Annexure-3 for the values used to generate the graph)

Figure 4 shows the earned value generated for the contractor under the LOB method. The graph speaks about the cost overrun as the earned value and the actual cost are higher than the planned value although both being almost equal. The project was under budgeted for the study. Since the LOB method deals with no multi-tasking it's was best appreciated by the contractor. It was found to be contented by both: client and the contractor.

Figure 4: Earned Value Report- (Technique: LOB; Approach: Contractor)

(Refer Annexure-4 for the values used to generate the graph)

4. RESULTS AND CONCLUSIONS

As explained in the previous chapter, the implementation of LOB gave much good results than CCPM. The LOB balance is a preferred technique for a villa project as it satisfied both the client and the contractor. The above graphs on the implementation of CCPM and LOB are self-explanatory. The study gave a clear output that LOB technique is best suited for a row housing construction. The comparative study gave the effect on the execution team which was an additional benefit. Also due to lack of awareness there was not much support from the execution team for the implementation of the above said system.

Previous research has found that the LOB method has given a good result for high rise buildings. We can also try to implement the same system for different types of construction like bridges, commercial buildings and so on as a part of extending the research. Finally to conclude the study, the LOB method is suggested for villa type construction.

ANNEXURES

The below table gives the values of EV, PV and AC for different WBS used to generate the above graphs.

Annexure-1 (CCPM- For Client)

Task Name	PV(INR)	EV (INR)	AC (INR)
Footings	248,731.30	248,731.30	248,731.30
Column casting till plinth level	21,601.21	21,601.21	21,601.21
SSM masonry	81,064.60	81,064.60	81,064.60
Plinth beam	98,287.02	98,287.02	98,287.02
Column and stair till FF Slab	201,118.86	201,118.86	201,118.86
FF Slab	426,977.14	426,977.14	426,977.14
Column and stair till SF Slab	122,338.30	122,338.30	122,338.30
F Slab	24,536.61	24,536.61	24,536.61
Column till terrace slab	103,610.48	103,610.48	103,610.48
Terrace Slab	640,080.00	640,080.00	640,080.00
OHT	60,746.24	60,746.24	60,746.24
MASONRY WORKS	358,659.04	358,659.04	358,659.04
GF	140,349.54	140,349.54	140,349.54
FF	145,535.68	145,535.68	145,535.68
SF	62,377.56	62,377.56	62,377.56
Masonry at terrace	10,396.26	10,396.26	10,396.26
Internal Plastering	250,036.09	250,036.09	250,036.09
GF	115,401.28	115,401.28	115,401.28
FF	94,244.37	94,244.37	94,244.37
SF	40,390.44	40,390.44	40,390.44
External Plastering	267,287.52	267,287.52	267,287.52
Servant Room/ Garden Room	39,799.75	39,799.75	39,799.75
Compound Wall	102,542.63	102,542.63	102,542.63

Annexure-2 (CCPM- For Contractor)

Task Name	PV(INR)	EV (INR)	AC (INR)
Footings	62,665.00	62,665.00	52,425.00
Column casting till plinth level	17,380.00	17,380.00	14,980.00
SSM masonry	38,060.00	38,060.00	32,100.00
Plinth beam	27,260.00	27,260.00	24,700.00
Column and stair till FF Slab	73,190.00	73,190.00	64,070.00
FF Slab	55,800.00	55,800.00	46,520.00
Column and stair till SF Slab	63,790.00	63,790.00	59,790.00
SF Slab	29,540.00	29,540.00	23,140.00
Column till terrace slab	8,780.00	8,780.00	8,780.00
Terrace Slab	25,210.00	25,210.00	19,290.00
OHT	35,290.00	35,290.00	30,650.00
MASONRY WORKS	220,780.00	220,780.00	203,660.00
GF	63,140.00	63,140.00	58,820.00
FF	54,370.00	54,370.00	47,010.00
SF	70,900.00	70,900.00	67,380.00
Masonry at terrace	32,370.00	32,370.00	30,450.00
Internal Plastering	242,460.00	242,460.00	226,140.00
GF	86,090.00	86,090.00	79,050.00
FF	94,000.00	94,000.00	87,920.00
SF	62,370.00	62,370.00	59,170.00
External Plastering	70,320.00	70,320.00	66,720.00
Servant Room/ Garden Room	53,250.00	53,250.00	48,770.00
Compound Wall	129,000.00	288,080.00	269,680.00

Annexure-3 (LOB- For Client)

Task Name	PV(INR)	EV (INR)	AC (INR)
Footings	248,731.30	248,731.30	248,731.30
Column casting till plinth level	21,601.21	21,601.21	21,601.21
SSM masonry	81,064.60	81,064.60	81,064.60
Plinth beam	98,287.02	98,287.02	98,287.02
Column and stair till FF Slab	201,118.86	201,118.86	201,118.86
FF Slab	591,676.11	591,676.11	591,676.11
Column and stair till SF Slab	122,338.30	122,338.30	122,338.30
SF Slab	332,387.75	332,387.75	332,387.75
Column till terrace slab	103,610.48	103,610.48	103,610.48
Terrace Slab	947,931.14	947,931.14	947,931.14
OHT	60,746.24	60,746.24	60,746.24
MASONRY WORKS	358,659.04	358,659.04	358,659.04
GF	140,349.54	140,349.54	140,349.54
FF	145,535.68	145,535.68	145,535.68
SF	62,377.56	62,377.56	62,377.56
Masonry at terrace	10,396.26	10,396.26	10,396.26
Internal Plastering	250,036.09	250,036.09	250,036.09
GF	115,401.28	115,401.28	115,401.28
FF	94,244.37	94,244.37	94,244.37
SF	40,390.44	40,390.44	40,390.44
External Plastering	267,287.52	267,287.52	267,287.52
Servant Room/ Garden Room	39,799.75	39,799.75	39,799.75

Annexure-4 (LOB- For Contractor)

Task Name	PV(INR)	EV (INR)	AC (INR)
Footings	29,540.00	23,140.00	22,220.00
Column casting till plinth level	7,320.00	7,320.00	5,560.00
SSM masonry	7,760.00	7,760.00	9,740.00
Plinth beam	13,000.00	10,000.00	9,160.00
Column and stair till FF Slab	28,426.00	16,576.00	23,466.00
FF Slab	37,940.00	15,440.00	35,380.00
Column and stair till SF Slab	38,800.00	33,500.00	26,260.00
SF Slab	25,440.00	11,440.00	22,880.00
Column till terrace slab	8,050.00	4,400.00	6,770.00

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Terrace Slab	18,510.00	8,360.00	49,830.00
OHT	9,730.00	6,480.00	6,210.00
MASONRY WORKS	79,400.00	79,400.00	62,920.00
GF	14,440.00	14,440.00	12,760.00
FF	29,560.00	29,560.00	20,920.00
SF	29,560.00	29,560.00	23,400.00
Masonry at terrace	5,840.00	5,840.00	5,840.00
Internal Plastering	101,040.00	124,457.00	50,680.00
GF	44,000.00	44,000.00	23,200.00
FF	42,800.00	42,800.00	19,000.00
SF	14,240.00	37,657.00	8,480.00
External Plastering	16,800.00	38,400.00	21,000.00
Servant Room/Garden Room	28,630.00	28,630.00	20,750.00

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