



Line of Balance- A Contractor Friendly Scheduling Technique

KEYWORDS

Line of Balance, scheduling, Construction Management, contractor, repetitive scheduling

Mr. Bhushan R.S

Sumedha, S-1319, 4th Cross, Bharathnagar 2nd Phase,
BEL Layout, Off Magadi Main Road, Bangalore-
560091, Karnataka, India

Prof. V. Srinivasa Raghavan

Srinivasa Nilaya, 4-322(D), Near KEB Sub-Station,
Ashok Nagar, Manipal- 576104, Karnataka, India

ABSTRACT *Due to the complexity of the contemporary construction projects the need for modern day construction project management techniques is at the zenith. Line of balance (LOB), which was devised in the early 1940's, is strength to the project management world especially to the construction domain. The line-of-balance (LOB) method of scheduling is well suited to projects that are composed of activities of a linear and repetitive nature. This paper discusses the enhancement instigated after the implementation of LOB method in the construction domain.*

1. INTRODUCTION

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 LOB techniques have taken a back Seat and have never been commercialized due to the explosion of systems based on Network Analysis and Critical Path Method (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 1980's.

The LOB technique for planning and scheduling repetitive projects such as houses, high rise buildings, 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.

2. LINE OF BALANCE- A EPHEMERAL NOTE

Repeating units are commonly found in construction industry such as typical floors in multi-storey buildings, houses in housing developments, stations in highways, pile driving, production of pre-cast concrete units, meters in pipelines network, long bridges, tunnels, railways, airport runways, or water and sewer mains. These construction projects are characterized by repeating activities, which in most instances arise from the supervision of a generalized activity into specific activities associated with particular units. Construction teams assigned to repeating activities often perform the work sequentially. The assigned teams repeat the same task in a number of repetitive units in the construction project, moving from one repetitive unit in the project to the next. Due to frequent team movement, construction of repetitive activities should be scheduled in such a way as to enable prompt movement of teams among the repetitive units, allowing for cost and time efficiencies. Also non-productive time spent in commuting from one location to another location is saved. To achieve these possible efficiencies, it is necessary to balance the teams. By such scheduling, a construction manager achieves continuity in the placement of all repetitive elements, thus capitalize on the productivity of labour and equipment. Successful scheduling should include proper sequencing of construction activities and understanding of interdependent activities. The resource requirements

for each activity are to be analysed and estimated, preferably in detail. If project resources are limited, the activity times and the resource based logic may be changed because of time base analysis of resources. Unlike traditional scheduling techniques, Line-Of-Balance (LOB) accounts directly for team work continuity as well as resource availability to facilitate effective resource utilization (Sherif Mohamed Hafez, 2004).

3. LOB IMPLEMENTATION

In order to generate a detailed preplanning of the construction job the methodology looks like:

1. The construction project is subdivided into "construction phases" each having interdependent activities which may be executed into a unique construction rate.
2. All the activities are listed sharing same resources. Possible dependencies between activities on different construction phases are verified. These are grouped together or being changed from one phase to another.
3. Optimum teams are designed: It is necessary to consider the selected construction technology and methods, as well as site constraints.
4. Construction speed for each team: The best teams as well as their construction rates will be assessed.
5. All the activities are divided into two groups: the main activities for each "construction phase" and a second group of secondary or complementary activities which usually are very fast with low labour consumption, and hence small duration.
6. The construction quantities for each construction area and the main activities are calculated: Construction volumes were calculated or each area. This is different than the usual budget all round volume calculations, because this one is directed towards its use for repetitive construction planning.
7. The time required to build each area is calculated: Divide the area volume by the construction rate of each team. This will yield different time periods for each activity.
8. The number of optimum teams to generate almost the same production time for every team working in the same construction phase is adjusted. In order to adjust the construction time to generate equal paces, the number of optimum teams is changed. Teams shall be designed in such way that all of them will be performing productive work continuously.
9. The line of balance scheduling is developed by plotting sequentially all the construction activities and balancing the teams in order to avoid conflicts into any floor. The total duration of the construction phases and the time buffer between consecutive ones, thus calculating their start and finish dates is calculated (Mendes, Fernando & Heineck., 1998).

4. LOB- STRENGTHS

One production scheduling and control technique which tries to surpass the CPM difficulties for multi-story building scheduling is the Line of Balance (LOB) technique. The LOB technique is very suitable for repetitive projects like residential buildings; however it may be adapted for non-repetitive projects as well. The main advantages of LOB schedule are its graphical presentation, easy understanding of the schedule and the goals of planning used in it (Sherif Mohamed Hafez, 2004).

5. LOB- WEAKNESS

LOB techniques were designed to model simple repetitive production processes and, therefore, do not transplant readily into a complex and unpredictable construction environment (Kavanagh, 1985). Due to the visual problems with the presentation of the LOB diagram, the use of colour graphics to differentiate between overlapping activities was recommended (Arditi & Albulak, 1986). The LOB was also attempted in a spread sheet format by introducing activities that runs concurrently. They confronted the complex relationships that their spread sheet had to express and concluded that it was practically meaningless to draw the output in the form of a diagram with an incomprehensible mass of flow lines. It was also mentioned that LOB could show clearly only a limited amount of information and a limited degree of complexity, especially when using the technique to monitor progress (Neale & Raju, 1988). There is no parameter to measure quality and to shortlist bottlenecks for the project at any given point of time. LOB is an indicative graphical technique which shows the allocation and start finish dates along the progress of the project. Al Sarraj (1991) revealed that the LOB method was not in acceptable form for general implementation in construction and, as a result of that, its use in the construction project management had been very limited.

6. A CASE STUDY ON VILLA PROJECT (G+ 2 FRAMED STRUCTURE):

The LOB methodology was adapted to villa project which was a G +2 framed structure on a trail run basis. The master schedule was drawn with 315 days fixed for the completion of structure work along with masonry activities. But after the implementation of LOB it was very difficult to use the LOB charts for the construction as there were too many activities were there to figure out. Also for a villa type construction the activities have to be executed back to back. So it's highly difficult for the team to find out the start date or the completion date using the graphical LOB chart. So we approached the conventional method of using schedule copy for the construction purpose.

To find the financial progress with respect to planned value, Earned Value Analysis was carried out every fortnight and the same was also done at the end of the project (Refer Fig.1). The graph gave us a well-shaped S-curve. It was found that there was no much variance in the Earned Value at the end of the project; except with some slips in between the project run. The earned value was marginally above the planned value (as shown in the graph) which indicates cost control and minimal cost overrun.

7. CONCLUSIONS:

The entire process of implementation of LOB technique was quite successful as we could see a lot of changes in the qual-

ity and speed of construction. Some of the advantages are listed below:

1. Using LOB for a villa type construction can help the contractor to focus more on the individual units which improves quality and speed of construction. Further it will avoid any rectification works.

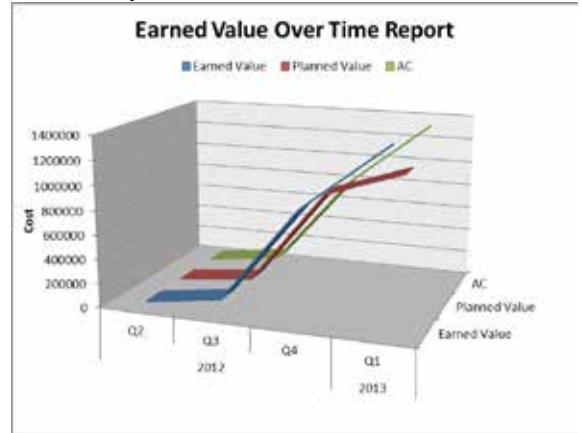


Figure 1: Earned Value Graph plotted at the end of the project

2. At any status date the progress (delay or ahead of schedule) can be figured out easily as we can plot the progress graphically and it can be compared to the planned.
3. The contractor can ensure maximum productivity as most of the resources will be at one single point and there is no parallel activity associated. Resources can flow from one activity to another after completing an activity.
4. Graphical approach also ensures a well-structured resource planning for the contractor.

Like all other project management techniques, LOB also has its own compensations and limitations. The advantages and limitations are governed by the synchronization between planning and execution team. There are huge gaps between the planning team and the execution team. We discuss about transparency, team work, cross functional consultation, optimal resource allocation, resource levelling, earned value analysis, productivity, project crashing etc. in closed settings; but actual practical situations are far distant from most of these concepts. The use of efficient and helpful software tools like Microsoft project, Primavera etc., are used only to fulfil contractual/ client requirements only. The need for emphasizing modern day project management techniques like CCPM, LOB, LSM etc., is at the zenith.

The main reasons for not implementing these tools in some of the projects/organisations are as follows:

1. Lack of awareness of the benefit of these tools among management.
2. Customisation of reports as per suitability of management in organisation.
3. Availability of trained manpower in organisations and human factors like resistant to change etc.

REFERENCE

- A.D. Russell and W.C. Wong (1993), "New Generation of Planning Structures," *Journal of Construction Engineering and Management* ASCE, Vol. 119(2), pp. 196-214. | Z.M. Al Sarraj (1990), "Formal Development of Line-of-Balance Technique," *Journal of Construction Engineering and Management*, ASCE, Vol. 116 (4), pp. 689-704 (1990). | D. Arditi and M.Z. Albulak (1986), "Line-of- Balance Scheduling in Pavement Construction," *Journal of Construction Engineering and Management*, ASCE, Vol. 112 (3), pp. 411-424(1986). | D.P. Kavanagh (1985), "SIREN: A Repetitive Construction Simulation Model," *Journal of Construction Engineering and Management*, ASCE, Vol. 111 (3), pp. 308-323 (1985). | Kris G. Mattila, A.M. and Amy Park, (January, 2003), "Comparison of Linear Scheduling Model and Repetitive Scheduling Method", *Journal of Construction Engineering and Management*. | M.H. Elwany, S.M. Hafez, I.E. Korish, and M.A. Barakat(1997), "Time Cost Trade-Off in Repetitive Projects," *Alexandria Engineering Journal*, Vol. 36 (1), pp.C39-C47. | R.H. Neale and B. Raju (1988), "Line of Balance Planning by Spread Sheet," *Building. Technology and Management*. pp. 22-27 (1988). | Ricardo Mendes Jr. & Luiz Fernando M. Heineck(1998), "Preplanning Method for Multi-Story Building Construction Using Line Of Balance", *Proceedings IGLC '98* | S.A. Suhail and R.H. Neale (1994), "CPM/LOB: New Methodology to Integrate CPM and Line of Balance," *Journal of Construction Engineering and Management*. ASCE, Vol. 120 (3), pp. 667-684. | Sherif Mohamed Hafez, (September 2004), "Practical limitations of line-of-balance in scheduling repetitive construction units", *Alexandria Engineering Journal*, Vol. 43, No. , Egypt