Study & Application of Line of Balance (LOB) Method for MIVAN Construction in Residential Project

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Abstract-Linear scheduling methods is best suited to projects that display repetitive characters but their use in the construction industry is limited. Line of balance is linear scheduling method that also makes use of network technology. The Line of balance method is well suited to projects that are composed of activities of a linear and repetitive nature. Line of balance method of scheduling for project comprised of work of repetitive natures which involved in housing project, urban residential development, roads construction, high-rise construction buildings, pipelines, such as houses, high rise buildings, precast concrete production etc. To monitor the project LOB method become easier to visualize and operate using set of flow line graph where Gantt chart graph do not give much details. It is important for project manager to handle the project within specific set of limitation where resources are available and optimum use. The overall objective of this study is to identify the total duration required by project for its completion and comparison with actual plan by using line of balance method and find out the float the project and representing the project with the use of flow line chart for repetitive nature of activities.

Keywords-Line of balance (LOB); Repetitive nature; Scheduling; flow line chart, Gantt chart.

I. INTRODUCTION

Line of balance (LOB) is a management control process used in construction where the project contains blocks of repetitive work activities, such as roads, pipelines, tunnels, railways and high-rise buildings. It is a control process for collecting facts relating to time, cost and schedule accomplishment, all the project related task is measured against specific plan. LOB shows the process, status of project, background of work, time and phase of project activities providing management with measuring tools.

LOB assists project management by:

1. Comparing a formal objective against actual progress.
2. Examining only the deviations from established plans, and gauging their degree of severity with respect to the remainder of the project
3. Dealing with problem and trouble causing areas and problem solving within specific constrains.
4. Forecasting future performance.
5. A programmed rate of completed units is met.
6. A constant rate of repetitive work is maintained.
7. Labour and plant move through the project in continuous manner such that a balanced labour force is maintained and keep fully employed.
8. The cost benefits of repetitive working are achieved.

Line-of-balance (LOB) is a variation of linear scheduling methods that allows the balancing of operations such that each activity is continuously performed. The major benefit of the LOB methodology is that it provides production rate and duration information in the form of an easily interpreted graphics format. The LOB plot can show at a glance what is wrong with the progress of an activity, and can detect potential future bottlenecks. Obviously, LOB allows a better grasp of a project composed of repetitive activities than any other scheduling technique, because it allows the possibility to adjust activities' rates of production. It allows a smooth and efficient flow of resources, and requires less time and effort to produce than network schedules (Arditi and Albulak 1986).

An early attempt to develop a computer application was made to schedule repetitive-unit construction by Arditi and Psarros (1987). It was limited to solving the basic LOB problem and was not designed to deal with the many implementation-related problems that were later identified. Clearly, there was a need to develop a computerized system that would make use of the principles used by Arditi and Psarros (1987) but that would also eliminate all of the associated shortcomings. A computer program that can easily and effectively be used by contractors could improve construction productivity significantly. [2]

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.

II. RESEARCH OBJECTIVE

The objective of this research study is to study Line of Balance (LOB) method to the project consisting the repetitive activities, as applying LOB the continuous monitoring of the project at each milestone. Using LOB resource allocation and resource levelling is done which gives effective force ratio, which helps in optimising the resources. Comparison between the cost delay and crashed cost can be done in one schematic diagram related to percentage increase in cost and planned cost. Slope of line is considered in line of balance scheduling, which indicates the rate of production of each activity, by which the monitoring process become easy. The increased in slope shows the higher rate of production, whereas the decreased in slope shows slow rate of production. Crashing of activity can be done to reduce the duration of activity. VICO software is used for the identification of the total duration required by project for its completion and comparison with actual plan by using line of balance method and VICO software, and find out the float in project and representing the project with the use of flow line chart for repetitive nature of activities.

III. METHODOLOGY

Drawing Line of Balance (LOB) diagram-

In LOB, time is plotted on X-axis and the units or stages on Y-axis. The production of an activity is the slope of production line and express in terms of units per time. The line of balance technique assumes that the rate of production of an activity is uniform. In other words, the rate of production is linear. The line of balance technique uses optimum crew size and man hours estimate.

The objective of LOB is to achieve a resource balance schedule by determine the number of crews to be employed in each repetitive activity. [10]

The rate of production is calculated by,
$$R = C/D$$

Where, R= Rate of production or Activity progress rate

C= Number of crews to be employed in repetitive activity per day
D= Duration in days

Calculation for crew size

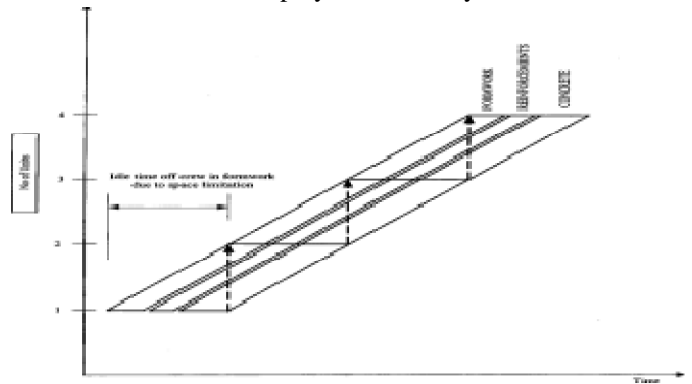C = Labours employed for activity/number of crews

Fig. 1 Planned activity using LOB (Source: D. Ardit, O. Tokdemir & K. Suh)
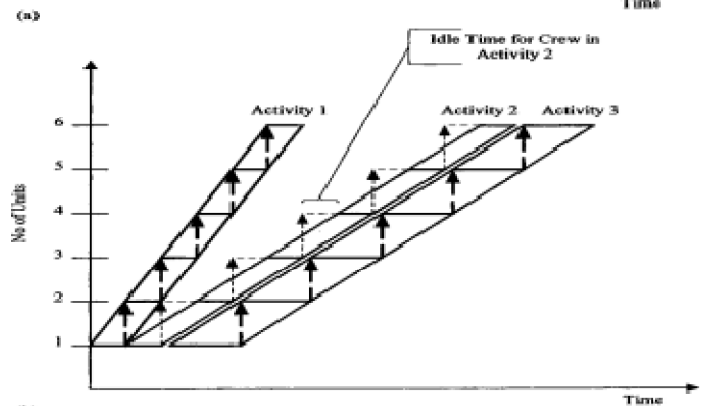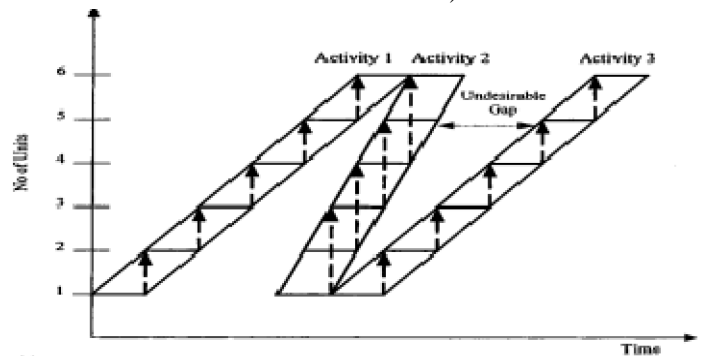

Fig. 2 Activity Progress rate as per actual work. (a) Undesirable schedule time-dependent activity 2 and 3 (b) Correct time dependent activity 2 and 3. (Source: D. Ardit, O. Tokdemir & K. Suh)
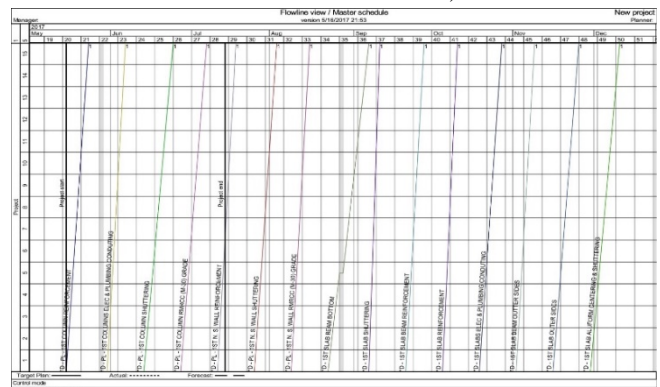

Fig 3. Flowline view using Vico Software

Comparison between bar charts and Line of Balance Technique.

- Bar chart facilitates focusing attention on specific objective, whereas LOB defines the objectives related to production rate, where monitoring is easy at any stage of project.
- In Bar chart, the result of planning activities can be clearly seen, where in LOB the results is carried out on reference with resource allocation and optimization.
- Activities on the critical and those with float can be easily identified, In LOB buffer are provided at start or end of activities, this facilitates the crashing operation.

Advantages of Line of Balance method

- The use of graphic and the visual intuitiveness provided by the separate activity types enables project manager, schedulers, owners, and construction personnel to better visualize the plan of action and more easily communicate the plan to everyone involved within the project.
- Benefits of this method allows the planner to plan a feasible schedule that is not sensitive to disturbances. The main advantage of LOB in scheduling projects is that it can convey important production information (eg. Work location, progress direction, and production rate) in an easy-to-visual graphic format.

Line of Balance Technique for resource planning

The LOB, repetitive project of n units, the network prepared for one unit has to be repeated n times and linked to others, this results in a huge network that is difficult to manage. This may cause difficulties in communication among the members of construction management team. CPM schedule is designed to optimizing project duration rather than dealing adequately with the special resource constraints of repetitive projects. They claim that LOB scheduling have the capability to ensure a smooth procession of crews from unit to unit with minimal conflicts and decrease idle time of workers and equipment. Furthermore, it helps avoiding many hiring and procurement problems in issues pertaining to the flow of labour and material used during construction. (Arditi et al. 2002)

In order to construct an LOB schedule, a network diagram for typical repetitive unit is prepared as a first step. Then, the man-hours as well as the optimum crew size for each activity.

Only one crew is assumed to work in a single unit and the crew spends (d) time on the unit before moving to the next similar unit. A natural rhythm rate for each activity is then defined as the optimum rate of output that are crew will be able to produce.

Resource Allocation

One of the main problem faced by the project manager is resource allocation, with the help of this allocation the critical activities can be identified. A project manager comes across resources constraints, there may be delay in the arrival of materials. The available may fall short of the requirements on some days, and there may be excess available on some days. The job of the project manager is to plan and allocate the resources for different activities so that the resources utilization is optimizes, with the resources constraints, the project manager may face following situations frequently,

- Resource Smoothing: in this surplus resources are available so some days and there is shortage of resources on some days, and time is the constraints.

- Resource Levelling: in this resources are fixed and schedule has to be limit. Through the project duration can be extended to satisfy the resource constraint it shall be done in such a way that the project duration is extended to the minimum possible extent and at the same time satisfying the resource constraint.

Crashing Activities

For crash able activity process rate is dependent on the number of crews or the resource assigned to the activity. Almost any activity can be performed with wide range of assigned resources. These assigned resources determine the activity duration along the units by manipulating the duration of activity during scheduling. It is possible to reduce or eliminate time delays resulting from logical constraints. Man-hour estimates were obtained from field personnel who had many years of site experience, technical field specification and previous records.

Earned Value Analysis

Earned Value Management is one of the most common techniques used to measure the performance of the ongoing project. Following terms comes under earned value analysis.

- Planned Value (PV):

Also called Budgeted Cost of Work Scheduled (BCWS), is the cost that is proposed to be utilized on an activity during a specific time frame.

- Actual Cost (AC):

Also called Actual Cost of Work Performed (ACWP), is the aggregate cost that is spent on an activity while its execution, during a specific time frame.

- Rate of Performance (RP):

It is the rate at which the project is progressing. Mathematically, it is the percentage of the work actually completed out of the total work that was scheduled to be completed till that point of time.

- Earned Value (EV):

Also called Budgeted Cost of Work Performed (BCWP), is the estimate of the value of the work completed, on the basis of how much work should have been completed and how much work was actually completed.

$$EV = PV \times RP$$

- Cost Variance (CV):

As the name suggests, Cost Variance calculates the deviation between the cost actually incurred and the planned cost. It checks whether we have gone according to our budgeted costs or not.

$$CV = EV - AC$$

- Cost Performance Index(CPI):

Cost Performance is used to estimate the projected or actual cost of completing the project based on the performance to date.

$$CPI = EV / AC$$

- Schedule Variance (SV):

Schedule Variance calculates the deviation between the actual and planned time taken to complete the project or an activity of a project. It checks whether the project has taken more or less time than that of the planned schedule.

$$SV = EV - PV$$

- Schedule Performance Index(SPI):

Schedule Performance Index is used to estimate the projected time to complete the project.

$$SPI = EV / PV$$

- Estimate At Completion(EAC):

Used to find the estimate cost of the project at completion, going by the present performance.

$$EAC = PV \text{ of whole project}/CPI$$

- Estimated time to complete:

Used to find the approximate time required to complete the project, going by the present performance.

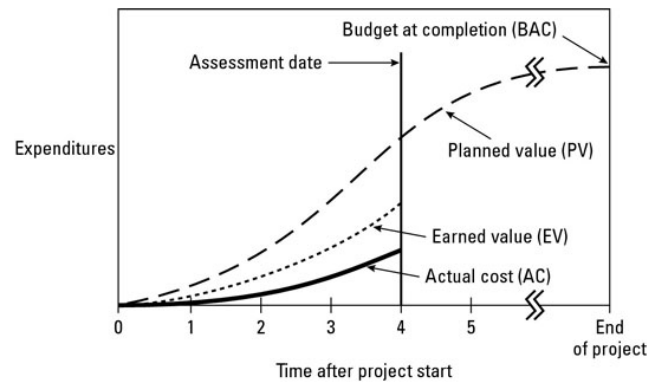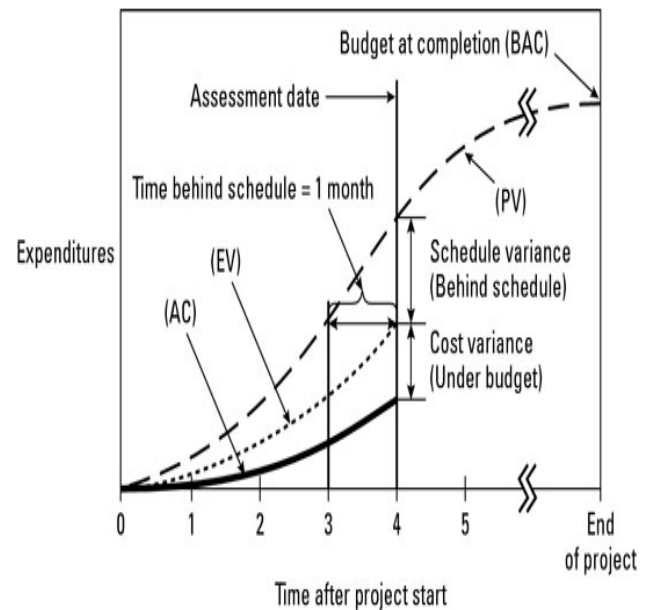$$=\text{Original time}/SPI$$

Fig .1

Fig. 2

With the help of EVA as shown in fig. 1 & fig. 2 we can approximate the amount of time behind or ahead of the approved schedule by drawing a line from the intersection of the EV and project date lines parallel to the x-axis to the PV

line. Doing so suggests that the project being described by the graph is about one month behind schedule.

IV. CASE STUDY

The Line balance method (LOB) is implemented on data collection shown in table 1 and Rate of production i.e. efficiency is calculated which will help in drawing the flow line of project progress. In MIVAN formwork construction for high-rise building consists of repetitive sets of activities. As an example the activity progress rate for actual duration is calculated and shown in table 1.Likewise activityprogress rate will be calculated for actual duration and further scheduling process of residential building will be carried out.

Table 1 : Activity progress of actual duration

Activity	Activity	(D)	L/day	C=No.of crews/da	R=C/D
A	1st - 2nd Column & N. S. Walls Reinforcement	8	27	27/1	3.37
B	1st - 2nd Columns & N. S. Walls Elec & Plumbing	8	7	7/1	0.87
C	1st - 2nd Column & N. S. Walls	8	26	26/1	3.25
D	2nd Slab Beam Bottom	8	20	20/1	2.5
E	2nd Slab Shuttering	8	20	20/1	2.5
F	2nd Slab Beam Reinforcement	8	14	14/1	1.75
G	2nd Slab Reinforcement	8	13	13/1	1.62
H	2nd Slabs Elec & Plumbing	8	7	7/1	0.87
I	2nd Slab Beam Sides	8	6	6/1	0.75
J	2nd Slab Outer Sides	8	5	5/1	0.62
K	2th Slab Aluform Centering &	8	40	40/1	5

Where,
        D = Duration in days
        L = Labors in number
        C = Number of crews per day
        R = Rate of production

V.CONCLUSION

In this research, the objective is to study and implement the LOB method and VICO control tool for the calculations of total project duration of high rise residential building. According to the result the better method for the scheduling of project will be selected from LOB and VICO tool for the calculation of flow line of project progress. LOB method and VICO tool are a graphical representation of repetitive activities where project manager can compare the planned and actual rate of production by which project manager can take suitable action over progress.

REFERENCES

[1] David Arditi, Onur B. Tokdemir and Kangsuk Suh (2001), "Scheduling system for repetitive unit construction using line-of-balance technology", Engineering construction and architectural management 2001 8/2,90-103.

[2] David Arditi, Onur B. Tokdemir and Kangsuk Suh (2013), "Challenges in Line of balance scheduling" J. Constr. Eng. Manage.2002.128.545-556.

[3] Robert b. Harris, Photios G. Ioannou (2014), "Scheduling projects with repeating activities", J. Constr. Eng. Manage. 1998.124.269-278.

[4] Mohammad A. Ammar, "LOB and CPM Integrated Method for scheduling repetitive projects", Journal of Construction Engineering and Management, Vol. 139, No.1, Jan(2013)

[5] Magdalena Rogalska, and Zdzislaw Hejducki, "Time Buffers in Construction Process Scheduling", The Journal of Civil engineering and Management, Vol. XIII.

[6] Recardo Mendes Jr. and Luis Fernando M. Heineck, (98), "Preolanning Method of multi-story building construction using line of balance", Precedding IGLC 98.

[7] Sherif Mohamed Hafez, (2004), "Practical limitations of line of balance in scheduling repetitive construction units", The Alexandria Engineering Journal, Vol. 43, No. 5.

[8] I-Tung Yang and Photios G. Ioannou, "Resource-Driven scheduling for repetitive projects: A Pull-System Approach"

[9] K.K. Chitkara, Construction Project Management, pp (205-210)

[10] H. Talodhikar and Prof Smita V. Pataskar, "Implemintation of Line of balance for high rise building" IJAFRSE.