Scheduling of Repetitive Construction Projects

4.1 Introduction

The repetitive projects are characterized by repeating activities . For example, the plastering activity for a tall building may be broken into plastering first floor walls , plastering second floor walls , and so on . Each floor here is a unit of the overall project. In such cases there is a need for a schedule that makes uninterrupted flow of resources from one unit to the next. Hence the scheduling problem that arises from multi-unit projects with repeating activities is subjected to resource continuity constraints as well as technical precedence constraints. The uninterrupted resources is not a problem assigned by the Critical Path Method (CPM) , nor by its extensions, such as time-cost tradeoff, limited resource allocation, and resource leveling. However , the problem had been recognized as will be explained by several scheduling methodologies for many years . Hence , CPM technique is less appropriate for scheduling repetitive projects and other techniques are suggested [1] .

4.2 Techniques of Scheduling Repetitive Construction Projects

Repetitive construction projects can be classified in several ways . One classification system suggests to group the repetitive projects according to the direction of work along the units. So there is the horizontal repetitive projects where the works are performed horizontally, as in pipeline construction or paving works. Another name for these construction projects is the continuous repetitive projects or linear projects due to the linearity of the geometrical layout and work . When progress is done vertically, the project is referred to as vertical

repetitive project, like high-rise building construction. The construction projects which involve the repetition of a unit network are called discrete repetitive projects [21].

For many years ago there was no categorization of methodologies related to scheduling repetitive construction projects to provide a framework and terminology for better understanding of the relative strengths of alternative methods [20]. There have been many attempts to generalize a collective term for the family of these scheduling methods. A selection of names given to such methods listed here [20]:

- Harmonograms
- Line-of-balance
- Flowline or flow line
- Repetitive scheduling method
- Vertical production method
- Time-location matrix model
- Time space scheduling method
- Disturbance scheduling
- Horizontal and vertical logic scheduling for multistory projects
- Horizontal and vertical scheduling
- Multiple repetitive construction process
- Representing construction
- Linear scheduling
- Time versus distance diagrams (T-D charts)
- Linear balance charts
- Velocity diagrams

Each term refers obviously to some application for the specific method . In this , the terms are effective communicators. Harris and Ioannou placed the term repetitive scheduling method (RSM) in an

attempt to address this diversity by defining a collective term [1]. However , the earliest term line of balance remains the most commonly used as a collective term even though it actually does not describe many techniques well [20] .

Techniques for scheduling repetitive projects may be deterministic or probabilistic regarding either estimating of durations of activities or duration of total project [7] . Optimization methods are used such as dynamic programming models and linear scheduling models . Optimization methods makes scheduling a dynamic process in terms of cost and time while maintaining the constraints of production rate and continuity of work of resources .They are often probabilistic in nature. Examples of these methodologies will be introduced in the next articles.

On the other hand , graphic techniques are deterministic in that they use unique duration for each activity such as the line of balance (LOB), the vertical production method (VPM) and the Linear scheduling method (LSM). Graphic methods plot repetitive activities as diagonal lines on X–Y graphs with time on the horizontal axis and location on the vertical axis. The slopes of the lines represent production rates of the activities. LOB, VPM and LSM techniques are very similar and are often treated as being the same . Some details of these methodologies will be given in the following articles .

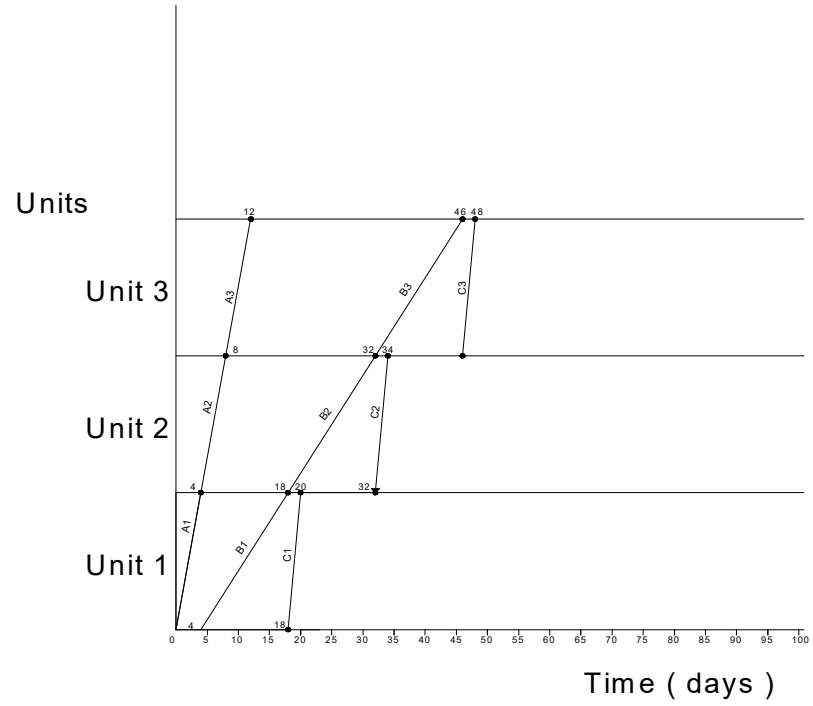
Another classification may be used . There are projects with discrete units like housing units and projects with continuous units like pipelines . For projects with discrete units many methods have been developed like : Line of Balance (LOB) , Vertical Production Method (VPM) , Time - Location Matrix Model , Time Space Scheduling Method , Disturbance Scheduling , Horizontal and Vertical Logic Scheduling for Multistory

Projects . Methods for highways, pipelines, tunnels, etc., where progress is measured in terms of horizontal length are : Time Versus Distance

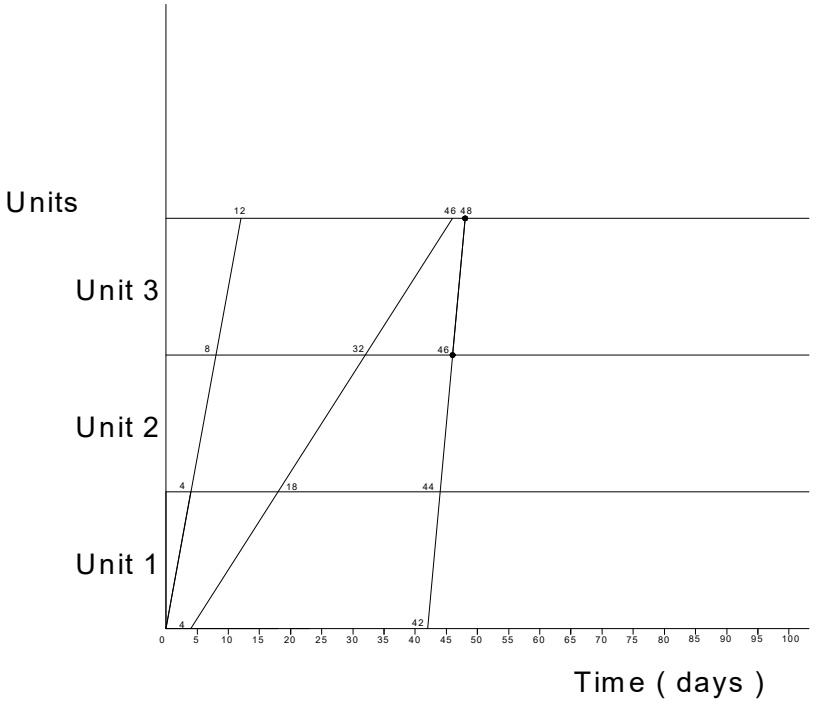
Diagrams , Linear Balance Charts , Velocity Diagrams and Linear Scheduling Method (LSM) [1].

4.3 The problem of delays

There are two main constraints that control the work sequence of resources, technological precedence and resource availability. In figure (4.1) there are two diagrams for a repetitive project consisting of 3 units, each requiring 3 activities (A, B and C). As shown in part (a) from the figure there are lags between activities . This means that resource availability constraints are satisfied, but technological constraints are not. This period of waiting is called “idle time”. One of the main objectives in scheduling repetitive projects is to minimize idle time that is to make resources working without interruption. Contractors usually pay for resources from their arriving to the site, until they finish work and leave. Therefore , it is important to minimize idle time and hence avoid extra costs [22] . This may be achieved by delaying activity start dates as it is shown in part (b) where the total project idle time has been eliminated without changing project duration. However it sometimes happens that it is impossible to make this without some increase in project duration . Optimization methods deals with this problem trying to reach a minimum duration for the project and in the same time a minimum cost of delay in individual activities [23] .



With idle times
a



Without idle times
b

Figure (4.1) Repetitive Project Example