

Automatic computation and visualization of linear project schedules using a software program developed on .NET framework

Tự động hóa việc tính toán và hiển thị tiến độ của các dự án tuyến tính sử dụng công cụ phát triển trên nền tảng .NET

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Abstract

This work develops a program for automatic computation and visualization of linear construction projects consisting of repetitive individual activities. The software program, named LPCV, has been constructed with Visual C# .NET framework 4.6.2. The program application is demonstrated via an exemplary construction project with 9 activities.

Keywords: Linear project; automation computation; schedule visualization; Visual C#, .NET framework.

Tóm tắt

Bài báo này phát triển một chương trình tính toán tự động và trực quan hóa các dự án xây dựng tuyến tính bao gồm các công tác lặp đi lặp lại. Chương trình phần mềm, được đặt tên là LPCV, đã được xây dựng với ngôn ngữ Visual C # trên nền tảng .NET 4.6.2. Chương trình phần mềm được kiểm chứng hiện thông qua một dự án xây dựng đơn giản với 9 công tác.

Từ khóa: Dự án tuyến tính; tính toán tự động hóa; trực quan hóa tiến độ; C #, .NET framework.

1. Introduction

In construction management, a construction project is typically regarded as a set of separated activities with their technical/managerial constraints. The nature of construction projects, which is determined by constant changes in operational environment,

pressures to maintain restricted requirements of schedules/costs with increasingly sophisticated construction methods, makes the task of project management/planning a difficult task [1]. The critical path method (CPM) is the commonly used approach for establishing construction project schedules [2]. Although

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the CPM is the predominant scheduling approach, there are other alternatives that can

be employed for project schedule planning.



Fig. 1 Examples of repetitive projects

The CPM coupled with a bar chart (a graphical representation of activities that are displayed in time scaled bar lines) can be appropriate for projects consisting of large numbers of small activities [3]. However, for linear construction projects which include a few activities that are executed in the same order or sequence (see **Fig. 1**), the CPM method and bar charts are not suitable. Linear construction projects include of a set of activities that are repeated in each unit [4]. After an activity is finished in one unit, it will be executed in the next unit of the project. Examples of linear projects include earth work, road construction, and utility piping.

Based on the direction of successive work along the units, linear projects with their repetitive activities are categorized into two major types [5]:

(i) Horizontal repetitive projects: This type includes roads, highways, tunnels, and pipelines.

(ii) Vertical repetitive projects: This type involves high-rise buildings and multiple housing units.

It is noted that for linear projects, resource continuity is often emphasized. This means that there is a desire to keep resources (e.g. working crews) working continuously without idle time. It is because idle time during employment periods leads to financial loss for contractors. Therefore, activities in linear projects should be

scheduled so that idle time of workers are ideally eliminated [4].

Due to its wide applications of linear projects, this study constructs a simple tool, named as Linear Project Computation and Visualization (LPCV) for quick establishment and display of linear project schedules. This tool has been developed with Visual C# on .NET framework version 4.6.2.

2. Linear Scheduling Computation

To establish a linear project schedule, managers typically need to perform the following steps [3]:

(i) Determination of individual activities

(ii) Estimation of production rates of activities

(iii) Determination of an activity sequence with consideration of logical relationships

A 2D diagram is typically used to represent a linear schedule with the x-axis displaying time and the y-axis displaying distance (or direction) of the project. The direction of the project can be either horizontal or vertical depending on the project nature. Each separated activity is presented as a line with its slope indicating the speed or rate of production. The steeper the slope is, the higher the rate of production is. In linear project scheduling, lines are generally not permitted to intersect because it literally means that the successor has gone ahead of the predecessor [3].

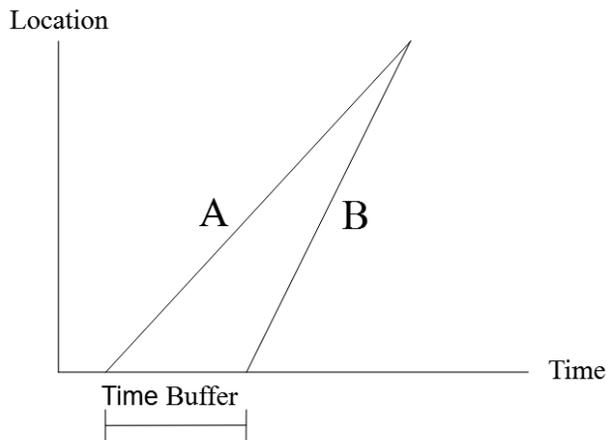


Fig. 2 Time buffer between a successor and a predecessor

In addition, a time buffer between two consecutive activities is needed if the rate of the successor (B) is faster than that of the predecessor (A). To compute the time buffer, it is a common practice to allow the activities A and B to accomplish simultaneously. Thus, the time buffer can be computed as:

$$\text{Time Buffer}_{AB} = \text{Duration}_A - \text{Duration}_B \quad (1)$$

3. Software program applications

This section of the article dedicates to demonstrating the LPCV software program application with one exemplary project. As mentioned earlier, the LPCV software program has been developed with Visual C# on .NET framework version 4.6.2. Therefore, the .NET framework version 4.6.2 (<http://www.microsoft.com/en-us/download/detail.aspx?id=53344>) must be installed in order to execute the LPCV properly. The graphical user interface of the software program is presented in **Fig. 3**. The program requires the project input information given in the form of a comma-separated values (CSV) file. The required information is described in **Table 1**.



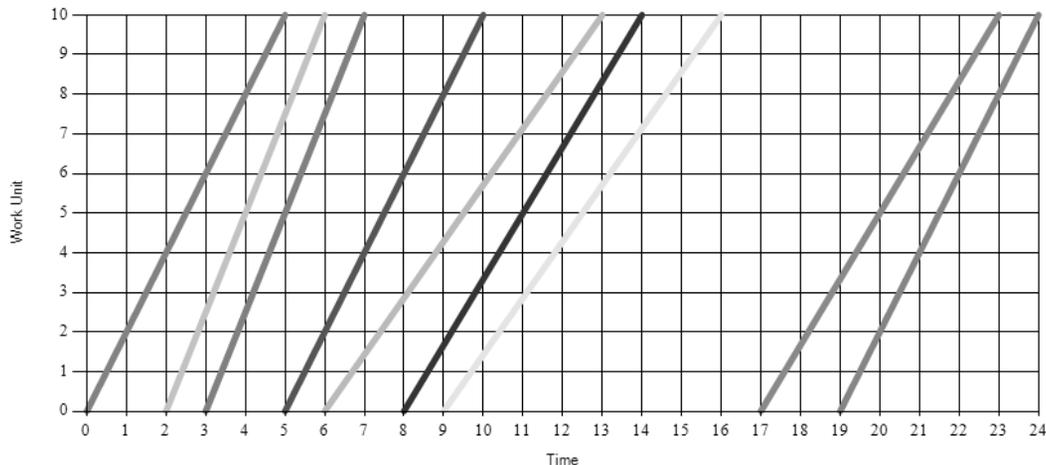
Fig. 3 Graphical user interface of the LPCV software program

Table 1. Project information

Activity name	Total required work (Man-hour)	Crewsize (Man)	Minimum buffer time (Day)	Total working unit	Working time per day (hour)
Column formwork installation	800	20	0	10	8
Column rebar placing	960	30	1	10	8
Column concrete pouring	1200	40	1	10	8
Column formwork stripping	800	20	2	10	8
Beam-slab formwork installation	3200	60	1	10	8
Beam-slab rebar placing	1800	40	1	10	8
Beam-slab concrete pouring	4000	80	1	10	8
Beam-slab formwork stripping	2400	50	7	10	8
Finishing	1600	40	1	10	8

The exemplary project includes 9 activities: column formwork installation, column rebar placing, column concrete pouring, column formwork stripping, beam-slab formwork installation, beam-slab rebar placing, beam-slab concrete pouring, beam-slab formwork stripping, and finishing. Each activity

necessitates information regarding total required work (man-hour), crewsize (man), minimum buffer time (day), total working unit, and working time per day (hour). The computation results obtained from the LPCV program are demonstrated in **Fig. 4** and **Fig. 5**.



(a)

- Column Formwork installation
- Column Rebar placing
- Column Concrete pouring
- Column Formwork stripping
- Beam-Slab Formwork installation
- Beam-Slab Rebar placing
- Beam-Slab Concrete pouring
- Beam-Slab Formwork stripping
- Finishing

(b)

Fig. 4 Computed project schedule (a) Linear scheduling result and (b) Activities

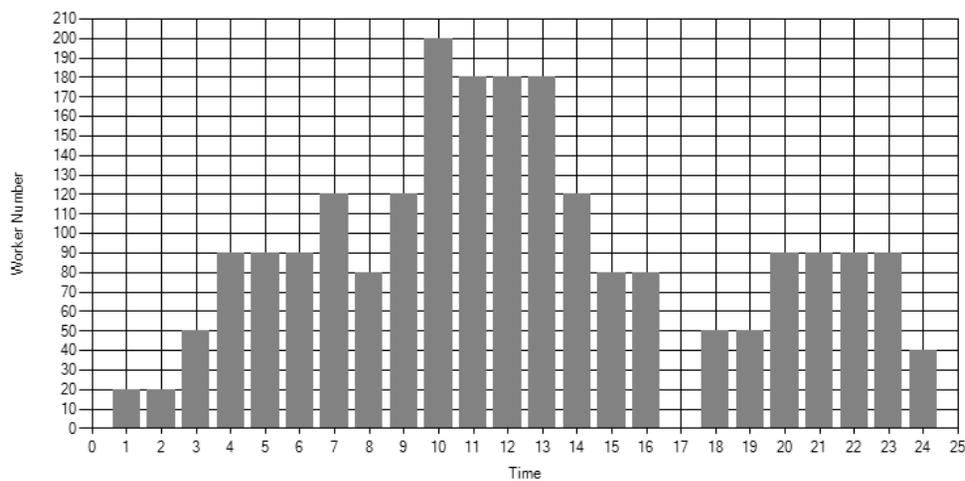


Fig. 5 Worker demand profile

4. Concluding remarks

This study has developed a simplified tool for automatic calculation and visualization of linear construction project schedule. The application of software program, named as LPCV, is demonstrated via an exemplary project consisting of 9 activities. The current version of the program only supports activities having constant production rates throughout the project. Future extensions of the current work may include the capability of scheduling activities with varying production rates as well as the integration of optimization algorithms to fine-tune project schedules.

Supplementary material: The LPCV program can be open accessed at: <https://github.com/NhatDucHoang/LPCV>.

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