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Using Critical Path Method for Project Planning and Scheduling with Primavera P6

Sumaia E. Eshim, Mohamed G. Elferjany
Department of Industrial Engineering and Manufacturing Systems,
Benghazi University, Benghazi, Libya

ABSTRACT : *Proper planning and scheduling are two important elements in determining the success of any project to ensure the project is complete on time, optimize resource allocation, and avoid cost overruns. The purpose of this study is to plan and schedule a two-floor coffee shop project using the Critical Path Method (CPM) with the help of Primavera P6 software. The results of this study show that the CPM is the suitable technique for determining the optimal completion time of the project. Primavera P6 also helped in identifying the critical activities that must be completed on time to avoid delays in the project and in providing detailed information about the entire project.*

KEYWORDS: *Project Planning, Project Scheduling, Critical Path Method, Primavera P6.*

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I. INTRODUCTION

A project is the culmination of all activities that have been carefully scheduled and planned with the goal of achieving certain objectives within a defined timeframe and budget. These activities are performed in a specific order that has been decided logically or technologically and must be completed within a specified amount of time in order to meet to achieve optimum project time [1]. The application of knowledge, skills, tools and technique to project activities to meet project requirements is known as project management [2].

Project management is an important side of the success of any project. The fundamental goal of project management is to identify and anticipate as many problems and issues as possible, and to plan, coordinate, and control activities to ensure that projects are completed as successfully as possible, despite any risks. as well as effective project management helps individuals and organizations to increase chances of the project's success through the application and integration of some of process, including planning, executing, monitoring and controlling the project work. Therefore, these the processes are the essential elements to ensure the projects will be completed on time, within budget, and to the required level of quality. In the last decades, two approaches that have been proven to be useful for planning, scheduling and controlling construction projects have been the Critical Path Method (CPM) and the Project Evaluation and Review Technique (PERT)[3].

The critical path method (CPM) is the most widely used in project scheduling that makes it possible to recognize the tasks required for project completion by knowing the activities' duration with certainty. The CPM method is to create a list of all tasks required to complete the project, the time each task takes to complete, the dependencies between the activities, and the resources required to complete those tasks. Today, it is one of the most important project management tools and is extensively used with all forms of projects, including construction, engineering, software development, manufacturing, product development, plant maintenance, among others. Several researchers have conducted studies that demonstrate the effectiveness of scheduling time using CPM in achieving time and cost efficiency. These studies have also shown that CPM networks are helpful in achieving these efficiencies. Additionally, a separate study has highlighted that CPM is well-suited for scheduling, formulating, and managing various activities in all types of construction work. This is due to the fact that CPM provides a schedule built on experience and observations, as mentioned by Atin and Lubis in [4].

Bodunwa and Makinde [3], described the critical path method as a mathematics-based algorithm for scheduling a series of project activities. It is an important tool for effective project management. Any project with interdependent activities can apply this method of scheduling. CPM analysis tools allow a user to select a

logical end point in a project and quickly identify its longest series of dependent activities (its longest path). These tools can 7 display the critical path (and near critical path activities if desired) as a cascading waterfall that flows from the project's start (or current status date) to the selected logical end point.

Another study conducted by Atin and Lubis [4] used the Critical Path Method (CPM), which is a network method that has a series of activity components with the longest total amount of time and shows the fastest time period of completion. The results of this study indicate that the use of CPMs is able to get the longest total amount of time with the fastest project completion period, project scheduling and project critical paths can be seen more clearly so that the project can be completed on time.

As well as a study conducted by Nafkha and Wiliński [5] presented critical path method, that aims to determine project schedule which ensure an implementation shortest time. Ultimately, however the optimal project duration is designated after solving human resource deficiencies or conflicts occurring in the generated schedule. At the same time, another method was developed called the Program Evaluation and Review Technique (PERT), which shows the probability of a project must be completed within a certain amount of time. the major difference between them is that PERT uses probabilities and multiple times, whereas CPM relies entirely on a single "best" time estimate

. Jain et al [6] provided the mathematical technique which helps the several project researchers in their research and development with several direct and indirect benefits. In 7 additions, explain the mathematical techniques with the help of two 'Network Planning Techniques' viz. 'Critical Path Method' (CPM) and 'Project Evaluation and Review Technique' (PERT). RanjithKumar et al. [7] Stated that planning and scheduling with Primavera software provide detailed information about cost control, time management, working hour management, update and monitoring and delay of activities, which enhance effectiveness in delivering services.

Deepika et al. [8] stated that Primavera is very useful in identifying critical activities that must be completed on time to avoid delays in the project. Dhinesh et al. [9] discussed a comparison between manual scheduling and Primavera scheduling and found that Primavera is efficient for scheduling the project and it also optimize the days of the project.

The above-mentioned literature that the critical path method (CPM) is the most common method for project planning and scheduling. As well as Primavera is effective for project scheduling in determining critical activities so that special attention can be given to those activities to avoid the delay in the project compared to manual scheduling. Therefore, the method used in this study is the critical path method (CPM) for project planning and scheduling using Primavera P6. The main aim is to find the critical path to determine the longest completion time.

II. METHODOLOGY

2.1 Data Collection

In this section, the procedures involved in establishing a two-floor coffee shop project are discussed. This the project can be implemented in a variety of locations, including educational, service, or recreational places. Data are collected from Al-NOURAN Contracting Company, including the prices of material, equipment, and labor, as well as the estimated duration of each activity. In order to illustrate how to proper planning and scheduling are done for a case study, the Primavera program is used. By entering activity details, establishing relationships between activities, and considering the data and costs collected, the critical activities, critical path, associated costs, and the projected completion time for the entire project are determined. the structure of the coffee shop project with a total construction area of 16 square meters is shown in Fig. 1.

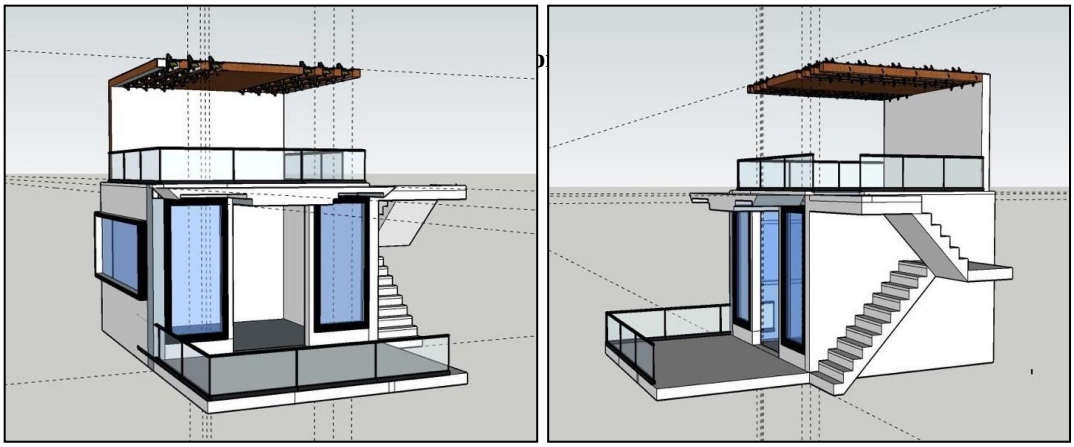


Fig. 1. The structure of the coffee shop project

2.2 Structuring of Project in Primavera P6

In this section the application PrimaveraP6 software as shown to determine the Critical Path Method (CPM), define critical activities, and perform network planning for coffee shop project. The basic steps involved in creating the project schedule using Primavera P6 software are as follows:

1. Adding a new project to the Enterprise Project Structure (E.P.S)

In this step, a new project is added to the E.P.S, named "Coffee Shop Project" after that, a project calendar is assigned. This calendar indicates the available work for the week is six days and the available work hours for each day are eight hours.

2. Creating W.B.S (Work Breakdown Structure)

The WBS is a basic tool for specification and categorization of work elements in project management to organize and define the total scope of a project into smaller, more manageable components [10].In this step, a Work Breakdown Structure (WBS) of the project is created. which divides the project into levels according to the drawings and specifications as shown in Fig 2. The major levels of WBS are as follows:

- Level One: The whole of the project.
- Level Two: Milestone, Preparatory Works, Engineering Works, Procurement, Construction Works, and External Works of the Project
- Level Three: The types of work (constructing, electrical, mechanical, architectural, and finishing)
- Level Four: The Activities.

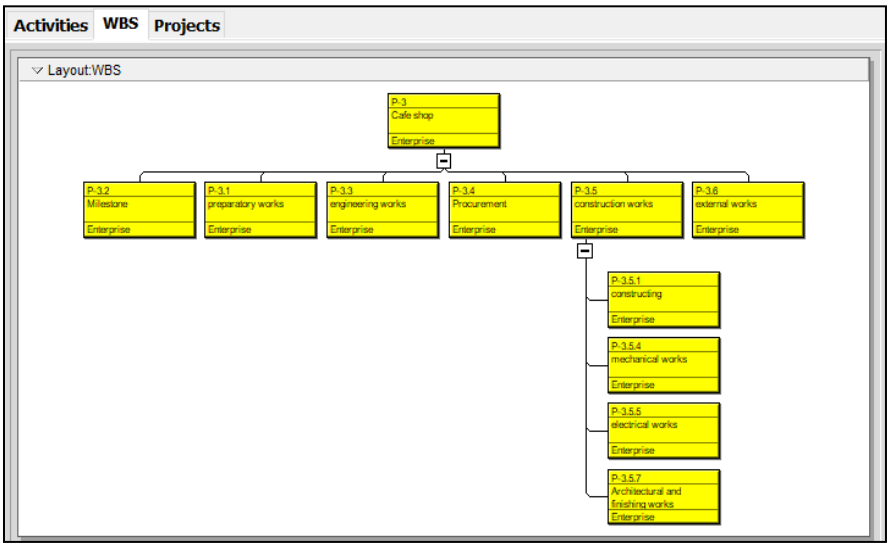
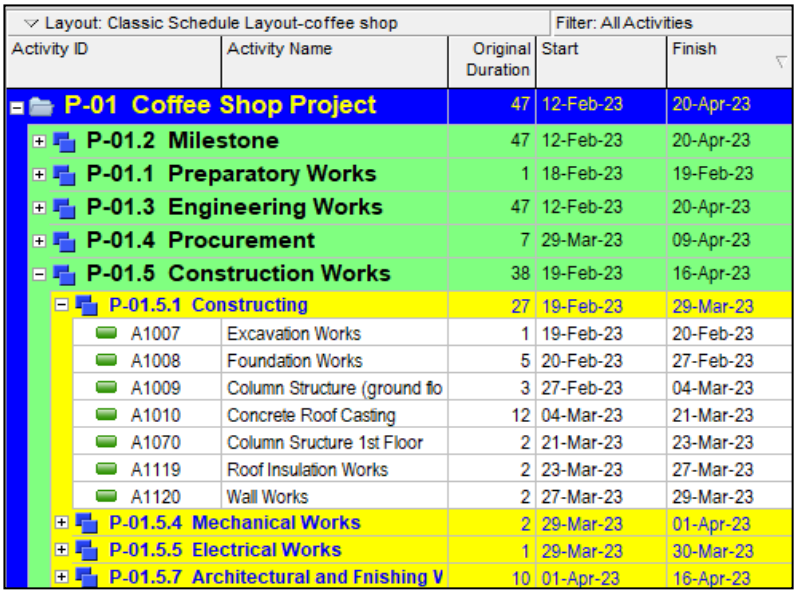


Fig.2. Creating a Work Breakdown Structure

3. Add Activities and Creating Relationships Between Activities

Activities are the fundamental work elements of a project, form the lowest level of a WBS, and are the smallest subdivision of a project. An activity has the following characteristics: activity ID, name, start and finish dates, activity calendar, activity type, activity codes, expense, successor and predecessor relationships, resources, lag time for relationships, and constraints for activities. By assigning succeeding, preceding activities that have a significant relationship to the overall project, a network is formed, enabling the scheduling of interconnected activities. Various types of relationships, such as finish to start (FS), start to start (SS), finish to finish (FF), and start to finish (SF), which establish the interdependence and sequencing of the project tasks, should be used to connect these activities to one another. Fig.3 shows the addition of activities to the WBS and the assignment of succeeding and preceding relationships.



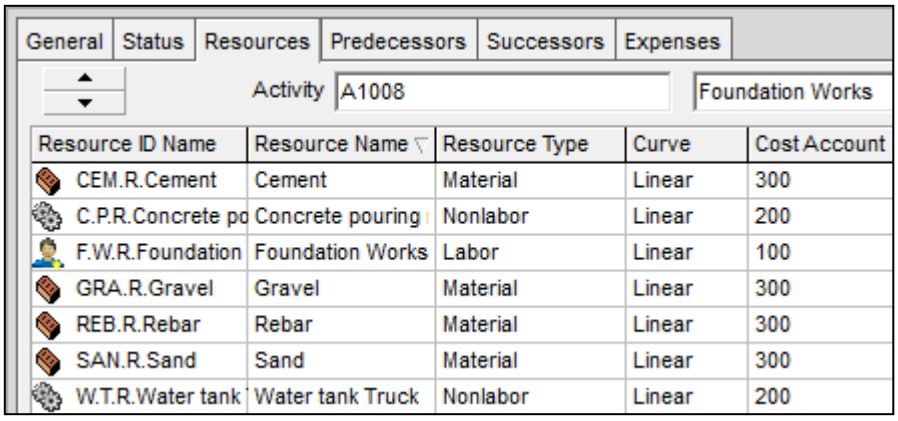
Layout: Classic Schedule Layout-coffee shop | Filter: All Activities

Activity ID	Activity Name	Original Duration	Start	Finish
P-01	Coffee Shop Project	47	12-Feb-23	20-Apr-23
P-01.2	Milestone	47	12-Feb-23	20-Apr-23
P-01.1	Preparatory Works	1	18-Feb-23	19-Feb-23
P-01.3	Engineering Works	47	12-Feb-23	20-Apr-23
P-01.4	Procurement	7	29-Mar-23	09-Apr-23
P-01.5	Construction Works	38	19-Feb-23	16-Apr-23
P-01.5.1	Constructing	27	19-Feb-23	29-Mar-23
A1007	Excavation Works	1	19-Feb-23	20-Feb-23
A1008	Foundation Works	5	20-Feb-23	27-Feb-23
A1009	Column Structure (ground flo	3	27-Feb-23	04-Mar-23
A1010	Concrete Roof Casting	12	04-Mar-23	21-Mar-23
A1070	Column Sructure 1st Floor	2	21-Mar-23	23-Mar-23
A1119	Roof Insulation Works	2	23-Mar-23	27-Mar-23
A1120	Wall Works	2	27-Mar-23	29-Mar-23
P-01.5.4	Mechanical Works	2	29-Mar-23	01-Apr-23
P-01.5.5	Electrical Works	1	29-Mar-23	30-Mar-23
P-01.5.7	Architectural and Fnishing V	10	01-Apr-23	16-Apr-23

Fig.3 Assigning activities and relationships

4. Add Resources to the Activity

After preparing the activity list, and determining the relationships, the resources and expenses required for each activity are added in this the step. Fig. 4 shows the resources loaded for activity (A1008), which requires a specific set of resources, including labor, materials, and equipment with certain quantities and prices.



General | Status | Resources | Predecessors | Successors | Expenses

Activity A1008 Foundation Works

Resource ID Name	Resource Name	Resource Type	Curve	Cost Account
CEM.R.Cement	Cement	Material	Linear	300
C.P.R.Concrete po	Concrete pouring	Nonlabor	Linear	200
F.W.R.Foundation	Foundation Works	Labor	Linear	100
GRA.R.Gravel	Gravel	Material	Linear	300
REB.R.Rebar	Rebar	Material	Linear	300
SAN.R.Sand	Sand	Material	Linear	300
W.T.R.Water tank	Water tank Truck	Nonlabor	Linear	200

Fig.4 Assigning resource for activity (A1008)

III. RESULTS AND DISCUSSION

3.1. Planning And Scheduling

Planning and scheduling for coffee shop project was performed using Primavera P6 (version 2019). This software automatically identifies the critical path, which consists of activities that must be completed on time to avoid delays in the overall project duration. To enhance visibility, critical activities are highlighted with red bars, as shown in the project's Gantt chart in Figure.5. The information on the schedule can be summarized as follows:

- The project start date is 12 February 2023 and the project finish date is 12 April 2023. The project had a completion period of 47 days.
- The project consists of a total of 33 activities, of which 23 are critical. These critical activities are coded as follows: [A1460, A1470, A1490, A1500, A1510, A1530, A1049, A1050, A1061, A1007, A1008, A1009, A1010, A1070, A1119, A1120, A1140, A1166, A1170, A1190, A1200, A1260, and A1290].
- A total of 46 resource types were used, including manpower, equipment, and materials.

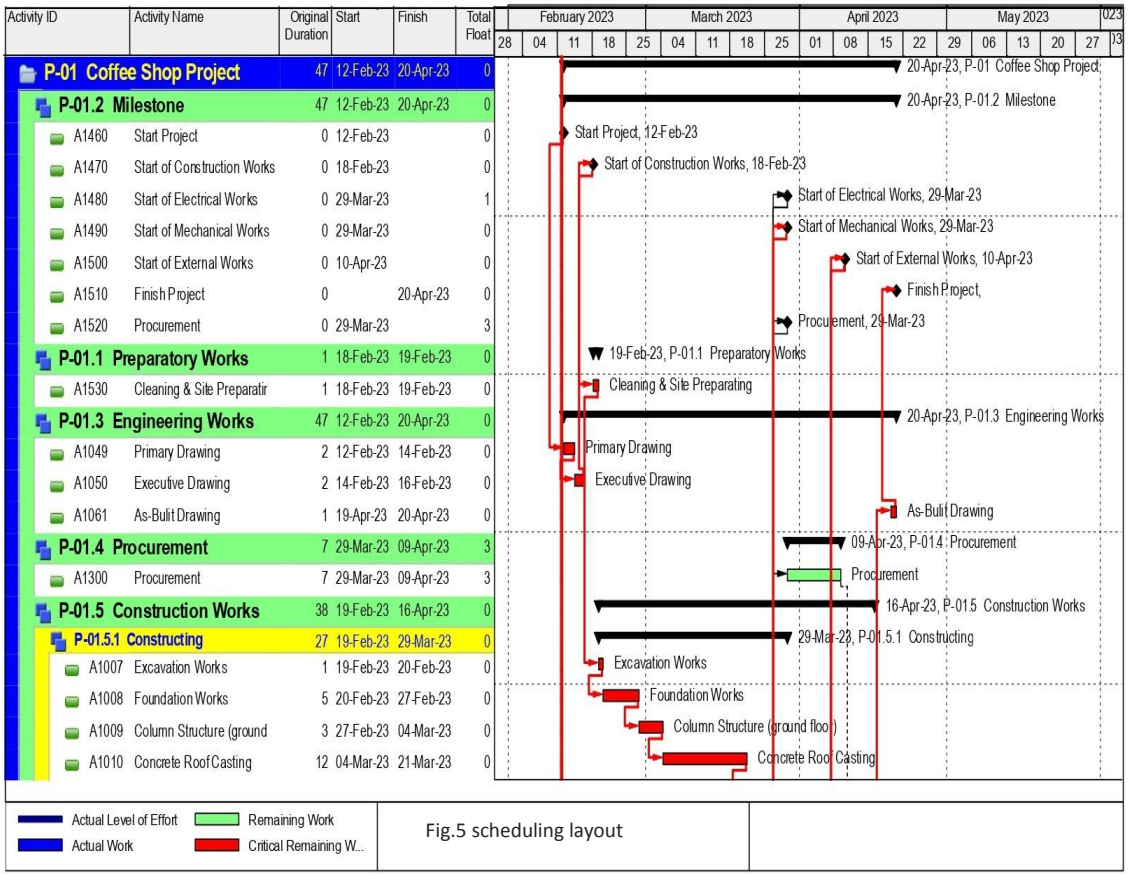


Fig.5 scheduling layout

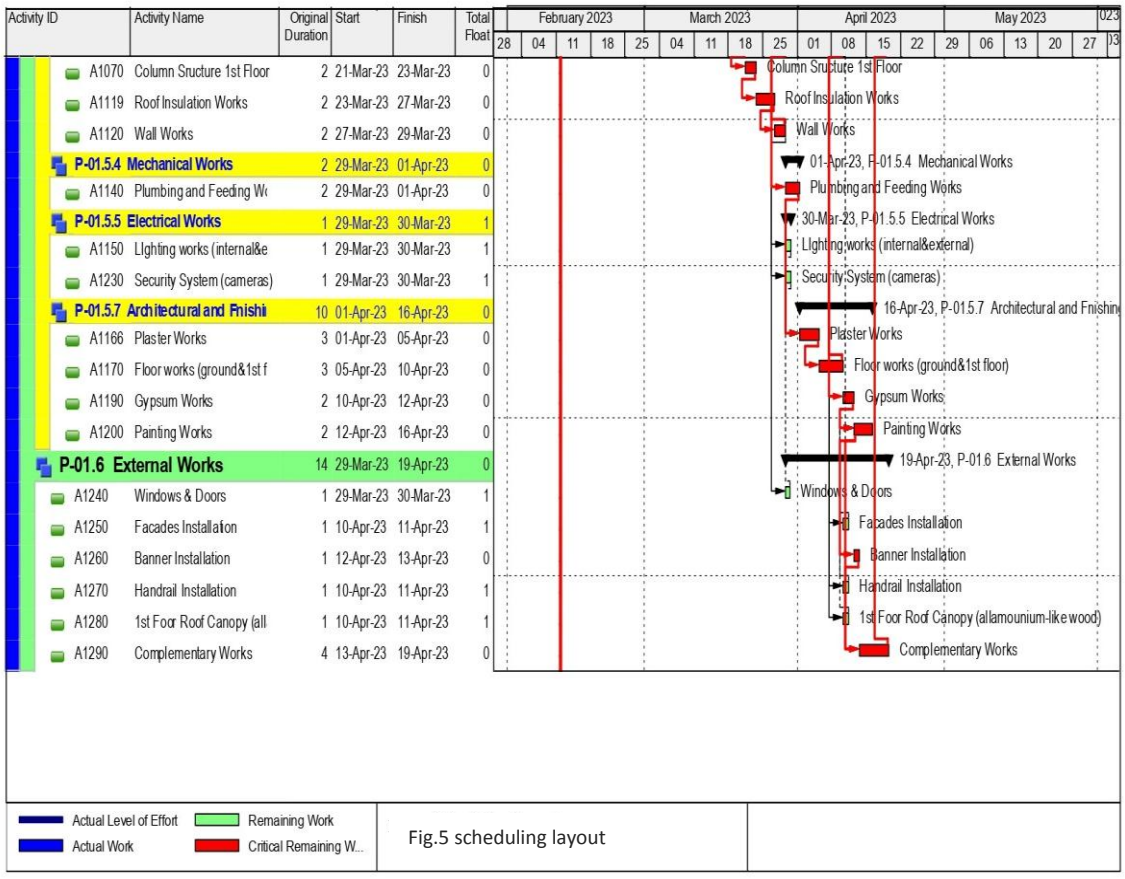


Fig.5 scheduling layout

3.2. Project Budgeting

After estimating the costs of materials, equipment, and manpower for each activity, the total budget for the project is determined as shown in Table 1, which shows that the total budget for the project is LYD 67,777.50. The weekly project cost of resources is summarized in Table 2.

Table 1. Estimated Cost of the Project.

No.	Activity	Cost, LYD
1	Preparatory Works	800
2	Engineering Works	1000
3	Procurement	21,700
4	Construction Works	19,150.50
5	Mechanical Works	1,600
6	Electrical Works	3,395
7	Architectural and finishing	8,292
8	External Works	11,840
	Total cost	67,777.50

Table 2. Project Cost Summary

Budgeted Cost	Budgeted Labor Cost	Budgeted Nonlabor Cost	Budgeted Material Cost
11-Feb-23	700 LYD	0 LYD	0 LYD
18-Feb-23	1,500 LYD	2,170 LYD	818 LYD
25-Feb-23	1,860 LYD	580 LYD	2,208 LYD
04-Mar-23	320 LYD	1,227 LYD	966 LYD
11-Mar-23	240 LYD	1,280 LYD	884 LYD
18-Mar-23	1,360 LYD	693 LYD	1,482 LYD
25-Mar-23	3,745 LYD	0 LYD	8,113 LYD
01-Apr-23	2,385 LYD	0 LYD	16,590 LYD
08-Apr-23	5,290 LYD	0 LYD	11,530 LYD
15-Apr-23	1,550 LYD	0 LYD	288 LYD

S-Curves and resource histograms illustrate the allocation and use of resources for the project, which include labor, materials, and equipment, over time as shown in Figures 6-8, respectively. These charts will help project leaders to evaluate whether expenditures are in line with budgeted costs and whether the project is on track in terms of resource usage. The S-curve also represents the percentage of early or late completion of the project, which shows whether the project is ahead or behind schedule, which can be observed in Fig. 9. The percentage of project delayed is shown by the red curve, ahead of schedule.

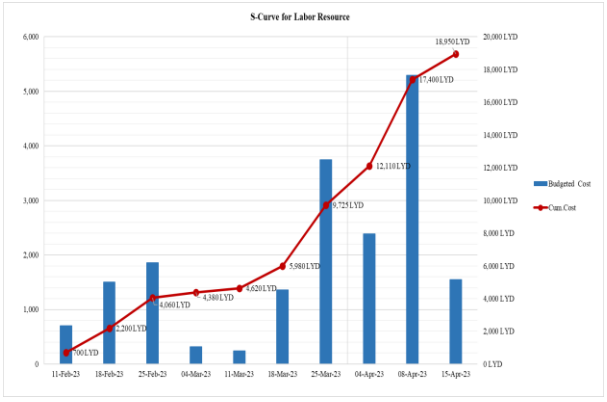


Fig. 6. Labor Histogram and S- Curve

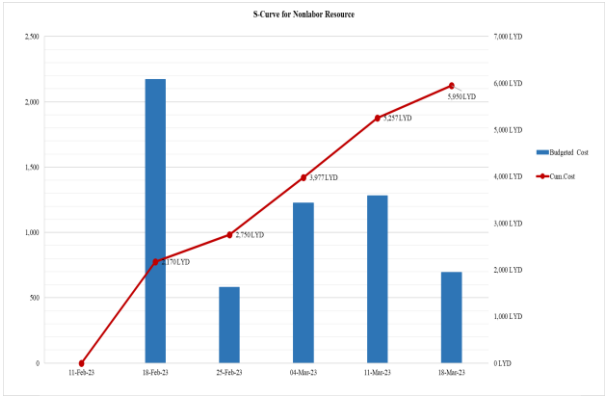


Fig. 7. Non-Labor Histogram and S- Curve

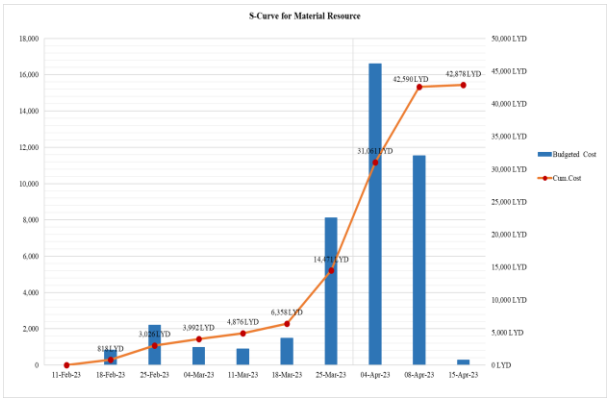


Fig. 8. Material Histogram and S- Curve

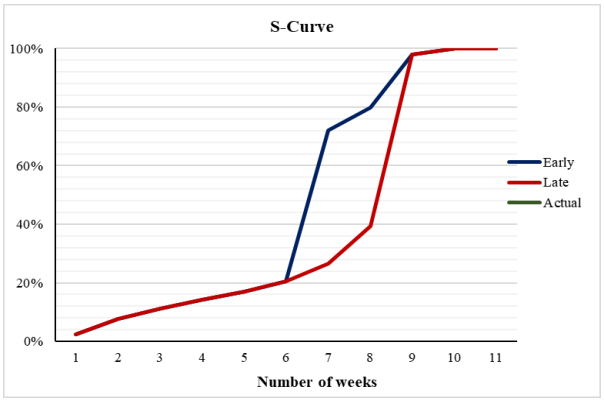


Fig. 9 S-curve of the project

IV. CONCLUSION

This study focuses on understanding the importance of project planning and scheduling to determine the activities needed to complete a project in a certain order and time frame. The Critical Path Method (CPM) with the help of Primavera P6 is used to plan and schedule a two-floor coffee shop project as a case study. Data are collected from Al-NOURAN Contracting Company. The results of this study show that the CPM is the suitable technique for determining the optimal completion time for a project. Primavera P6 helps in determining critical activities that must be completed on time to avoid delays in the project, and also in providing detailed information about the entire project. According to this study, we recommended Al-NOURAN Contracting Company to use Primavera software in future projects to simplify the management of activities, resources, and deadlines.

REFERENCES

[1]. Agyei, W. (2015). Project planning and scheduling using PERT and CPM techniques with linear programming: case study. *International journal of scientific & technology research*, *4*(8), 222-227.

[2]. Singh, H., & Williams, P. S. (2021). A guide to the project management body of knowledge: Pmbok (®) guide. In *Project Management Institute*. Bodunwa, O. K., & Makinde, J. O. (2020). Application of Critical Path Method (CPM) and Project Evaluation Review Techniques (PERT) in Project Planning and Scheduling. *J. Math. Stat. Sci*, *6*, 1-8.

[3]. Bodunwa, O. K., & Makinde, J. O. (2020). Application of Critical Path Method (CPM) and Project Evaluation Review Techniques (PERT) in Project Planning and Scheduling. *J. Math. Stat. Sci*, *6*, 1-8.

[4]. Atin, S., & Lubis, R. (2019, November). Implementation of critical path method in project planning and scheduling. In *IOP Conference Series: Materials Science and Engineering* (Vol. 662, No. 2, p. 022031). IOP Publishing.

[5]. Nafkha, R., & Wiliński, A. (2016). The critical path method in estimating project duration. *Information Systems in Management*, *5*(1), 78-87.

[6]. Jain, V., Sethi, P., Arya, S., Verma, R., & Chawla, C. (2020). Project Evaluation Using Critical Path Method & Project Evaluation Review Technique. *Wesleyan J. Res*, *13*, 1-9.

[7]. RanjithKumar K, Sridhar N, Sakthivelu K, Saran G, Monika N R (2017), "Planning and scheduling of commercial building using primavera p6 -case study", International Journal of Intellectual Advancements and Research in Engineering Computations (IJIAREC), ISSN:2348 2079, Volume-5, Issue-1

[8]. Deepika K, Suchithra S (2016), "An Exploratory Study on Effective Time Management of a Project", International Journal of Current Trends in Engineering & Research (IJCTER), e-ISSN 2455–1392, Volume 2, Issue 3, pp. 151 – 157

[9]. Dhinesh M, Kaleeswaran S, Manikandan Ashok S (2017), "Planning, Scheduling and Tracking of Residential Building Using Project Management Software", SSRG International Journal of Civil Engineering- (ICRTCETM) - Special Issue, ISSN : 2348 – 8352

[10]. Handayani, W., & Nofiani, D. Construction Project Planning and Scheduling: A Case of Inlet Separator Fabrication. Journal of Economics, Finance and Management Studies, Volume 4 Issue 11 November 2021, ISSN (print): 2644-0490, ISSN (online): 2644-0504.