



Research article

Computer-based analysis for design and schedule management for commercial buildings

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Abstract: Civilization in a country is measured by the growing number of urban cities. More than 50% of the global population stays in cities, and, in some other countries, it even reaches up to 80%. In India, the percentage is 35% live in urban areas, and it has been increasing rapidly over the years. At present, most of the construction projects in India are experiencing project delays and cost overruns. The main reason for this is that construction activities are implemented without proper scheduling, planning, and execution. The project progress time is required a proper timetable for more efficient execution. Scheduling aids in delivering the project more efficiently through the use of techniques like bar charts and the critical path method (CPM) to visualize the activities of the project. Bar charts could also be applied as a selective booking tool for arranging, but they should be subsequently supplemented by a rationale-based method like the CPM. Primavera is a project management software tool that makes use of this CPM logic to schedule the project and allocate resources. This paper analyzes the application of project management software in the ongoing construction project of a commercial building that is using a conventional method. As a part of our research, the activities and operations of the project were recorded and monitored on a daily basis through the use of Primavera. The consequences of delays in the project were forecasted by using software, and the resources were sequenced for utilization accordingly. This process in turn facilitates the optimization of resources and completion of the project as per the schedule. The results of the study can be applied to any construction project for the sustainable utilization of resources. This study entailed ongoing construction project monitoring and recording of the operational activities through the use of Primavera software to facilitate the sustainable management of resources. By using this technology, the resources can be utilized in a sustainable manner as per the schedule. Similar projects of the same size and budget can thus achieve better results.

Keywords: project management; scheduling; CPM; Primavera; construction project

1. Introduction

Many studies have recommended that more environmental and sustainable cities primarily focus on green spaces, infrastructure, and environmental quality. The rapid growth of urbanization requires that the development of construction projects maintain the urban population's standard of living [1]. The construction industry in India has become more competitive and stringent; due to this, the project managers are forced to be more effective before commencing each aspect of the construction activities [2,3]. The scheduling and planning activities of a construction project will optimally balance the important factors of time, quality, scope, cost, and work estimates in a sequential network of activities [4,5]. Each scheduling method has its own benefits and shortcomings. In any case, the timetables are best introduced in the bar diagram structure to maximize comprehensibility [3]. These bar diagrams are enhanced by a suitable arrangement strategy for observing the advancement of the activities.

1.1. Purpose of work schedule

The work scheduling in construction projects serves the following purposes:

- a) It improves the plan.

The bar chart-type work plan gives the improved form of the work plan, which can, without much effort, be able to properly illustrate the activities of arranging, coordinating, executing, and control of the venture [5].

- b) It improves the timetable.

The plan for getting work done shows the arranged timetable of exercises, and information astute while putting the work plan on a schedule premise; it thinks about the decreased effectiveness of assets to antagonistic climatic conditions and different variables. It confirms the cutoff times required for the undertaking and accomplishment of the achievements [6].

- c) It streamlines the assets utilized.

A plan for getting work done assumes the most efficient utilization of the materials, labor, and hardware. It accommodates sudden changes, which may occur. Asset streamlining is accomplished through the deliberate usage of the buoys of non-basic exercises [1].

- d) It estimates the information assets and predicts the yield.

A plan for getting work done optimizes the estimation of assets and provides an example of asset utilization [7].

1.2. Project network analysis

Undertaking network investigation is a conventional term covering all of the organization strategies utilized for the arrangement, planning, and control of ventures. The three most regularly utilized methods are as follows:

1. Basic technique (CPM)
2. Task assessment and audit procedure

3. Priority network investigation (PNA), out of which CPM is carried out by Primavera [7].

Their normal highlights are the utilization of the organization model for the portrayal of the timetable for the task, the application of a basic method to decide the project timeline, the distinction of basic activities, and the utilization of organizational analysis procedures to maintain the goals according to the timetable. Yet, every one of these methods has an unmistakable model with a shifting field of use [4].

1.3. Project planning

Planning is the first thing to initiate for any project. Planning aims at improved performance and to balance the golden triangles of time, quality, cost, and scope of the project for successful completion. Planning leads to providing clear instructions, resource utilization, risk analysis, and milestone achievements in advance before project initiation [3]. Planning specializes in the formulation of a time-based plan of action for coordinating various activities and resources to achieve the assigned goals [8]. Before scheduling, the preliminary planning involves the initial formulation of the project, where construction planning is divided into the following major steps which are explained in Table 1:

- a) Planning Time
- b) Planning Resources
- c) Planning Implementation

Table 1. Methodology for preliminary planning.

Stages	Planning Process	Techniques/Methods
Planning Time	Separating project work, creating time network plans, and booking work.	Work breakdown, Network examination, Gantt graph, Line of equilibrium strategy, Time-restricted planning, and Resource-restricted booking
Planning Resources	Determining asset necessities, Arranging labor necessities, Arranging material prerequisites, Arranging gear acquirement, Planning authoritative designs, Budgeting Costs, and Dispensing assignments and assets.	Determining labor planning, Material Booking, Equipment choice and booking, Cost arranging, and planning, and Resource assignment
Planning Implementation	Forming checking philosophy	Asset efficiency control, Time control, Contribution control, and Budgetary control

1.4. Objectives

- a) To schedule the entire project sequences within the time frame using Primavera.
- b) To reduce the cost by monitoring and allocating resources accordingly.
- c) To measure the practical durations required to carry out construction activities.
- d) To track the project progress and analyze the reasons for delays and cost overruns.

2. Methods and data sources

In order to understand the urban built environment, the methodology adopted in this research study is the construction scheduling technique application modeling which is used to improve and optimize the time delays, resource over-allocation, and budget overruns for the successful completion of the project [9]. This study aims to develop scheduling and planning on a commercial building for effective optimization over the traditional approach which was usually adapted to in-site methods in construction projects.

The research question was analyzed in depth by adjusting quantitative project data using Primavera P6 project management software to compile detailed scheduling and planning.

In order to showcase the major differences between modern software management and traditional methods, an ongoing project that uses Microsoft Excel for scheduling and planning a commercial building of G+3 in Nellore, India was selected for our study. The data collection required for this project like manpower, resources, machinery, and BOQ has been collected from the real-time data of the project. Due to client privacy reasons, the company profile details are protected and all other project-related specifications are underpinned. To demonstrate the major differences between modern software management and traditional methods, we chose an ongoing project using Microsoft Excel to schedule and plan a G+3 commercial building in Nellore, India. The data collection of manpower, resources, machinery and bill of quantities required by the project has been collected from the real-time data of the project. Company file details are protected for client privacy reasons and all other project related specifications are supported. Project data collected from these sources is then executed in Primavera P6 to differentiate and highlight the advantages of using Primavera versus traditional methods.

Total Built-up Area: 30,000 Sq. ft

- a) Type of the Project: G+3, Commercial Building
- b) Floor Wise BUA: 6,000 Sq. ft
- c) Total Project Cost: 4.18 Crores; (\$5,58,356 USD)
- d) Contract Period: 5 Months
- e) Nature of Contract: Item Rate Tendered Contract
- f) Project Start Date: 31st Jan 2020
- g) Project Finish Date: 09th Jun 2020

In data analysis and interpretation, the project data will be entered periodically and will figure out the work schedule, delay expectations, cost, and resource optimization, so as to achieve better project output. The final output of the study will give a clear understanding of the usage of project management software, thereby speeding up the construction process and making project execution more cost effective and efficient.

3. Results and discussions

The main data collected from the project are programmed in Primavera P6 to allow proper scheduling, planning and optimization of the construction projects. The data interpretation and data analysis have been carried out to address the problems faced by the traditional method. The key finding of this research study was based on the five most important functions in construction activities:

- i) Scheduling;
- ii) Planning;

- iii) Resourcing Allocation & Leveling;
- iv) Monitoring;
- v) Controlling.

It has been found that most of the traditional projects in India don't follow this hierarchy and simply repeat the ii, iii and iv functions multiple times leading to poor planning and scheduling process [10]. Thus, by using project management software, Primavera will help design work breakdown structures (WBS), develop schedules, plan accordingly, allocate resources to activities, track progress, and manage and control work fronts.

3.1. Bar chart method of work schedule: Gantt charts

A venture work-breakdown system empowers partitioning of the undertaking work into progressive work breakdown levels of sub-projects, assignments, work bundles, and exercises. Every action in WBS addresses a recognizable lower-level undertaking structure that devours time, quality, and assets [8]. The project calendar covers the project's life cycle in a tabular or bar chart from the initiation stage to the project handover. This commercial project calendar details and its paths are invariably represented in a bar format of Figure 1.

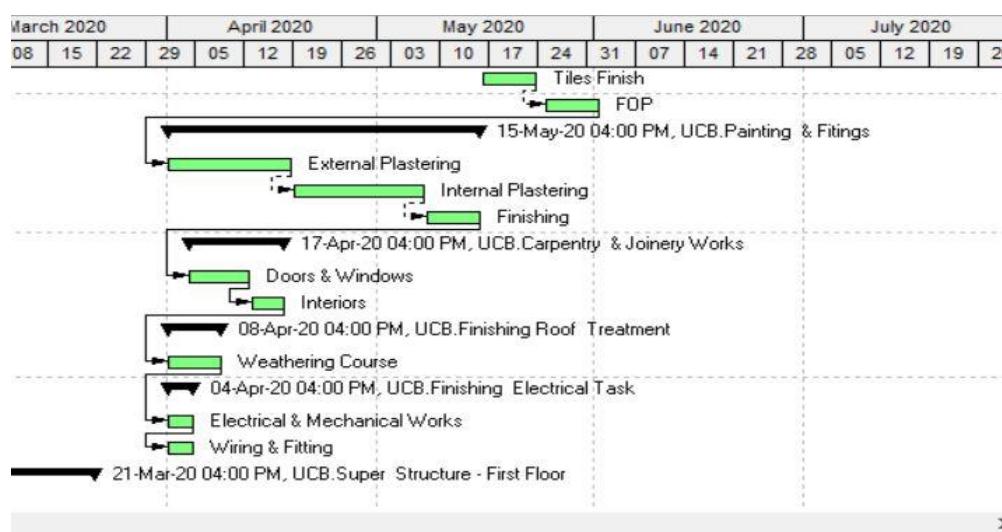


Figure 1. Project Scheduling in Gantt chart using Primavera.

3.2. Interpretation of practical problems (Delays)

In case of any delay in the commencement of a single activity due to many practical reasons, other activities are also affected. The consequences of these delays can be predicted using the Primavera. For instance, the activity of painting and fittings works in finishing is delayed due to the local Covid-19 lockdown. Since it was an activity that appeared on the critical path, the entire duration of the project was delayed by 21 days, this will be tedious to execute the rest of the tasks without knowing the seriousness of the problem.

Figures 2 shows the network before the delay, which also shows the start and finish date of the activity enlightened in blue color. Here, the change in the activity network was happened due to the delay of a single activity (Finishing). The software itself envisages the start of the successor activities

depending upon the defined relationships. The yellow circle in Figure 3 shows the change in the activity network due to the delay of a single activity (Finishing). The software itself envisages the start of the successor activities depending upon the defined relationship during the program.

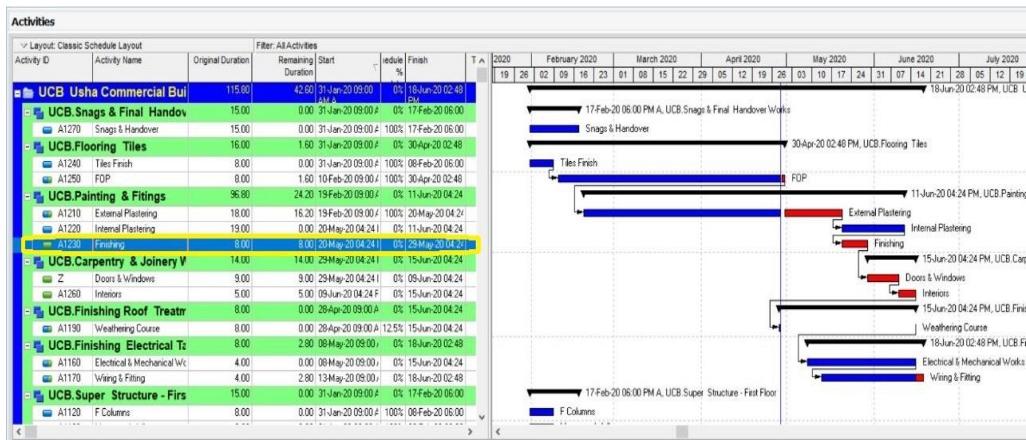


Figure 2. Expected commencement of the activity (Fittings Finishing).

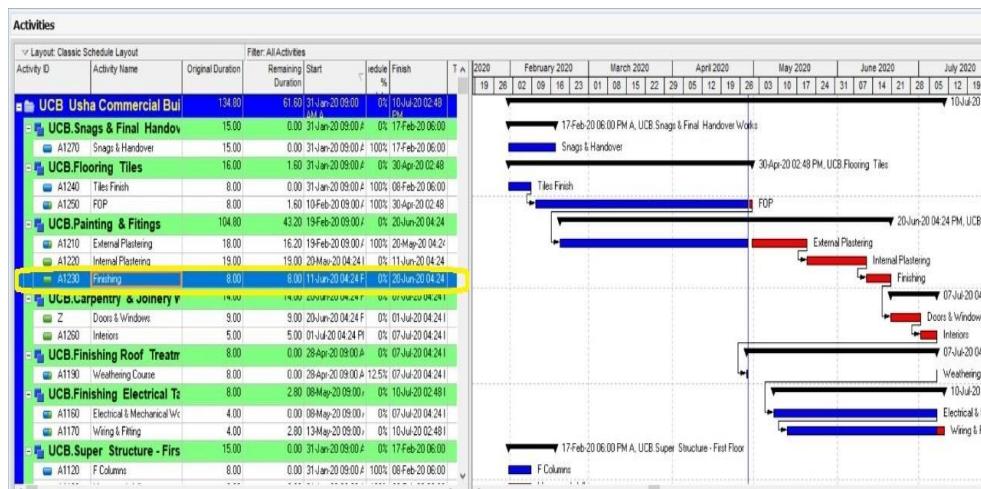


Figure 3. Change in network activity due to delay in finishing.

3.3. Allocations of resources

Resource allocation helps to reschedule the project tasks so that limited resources are used efficiently and unavoidable project delays are minimized. The resources are allotted to each activity according to the necessity with their units of measure, the price per unit, and the total quantity of resources to be utilized. The maximum and the minimum quantity of resources available per unit of time should be mentioned so that the software allocates resources according to the schedule and duration of the activity. In Figure 4, we have defined the resources for the activities to instance the resources of the activity roof slab are enlisted below.

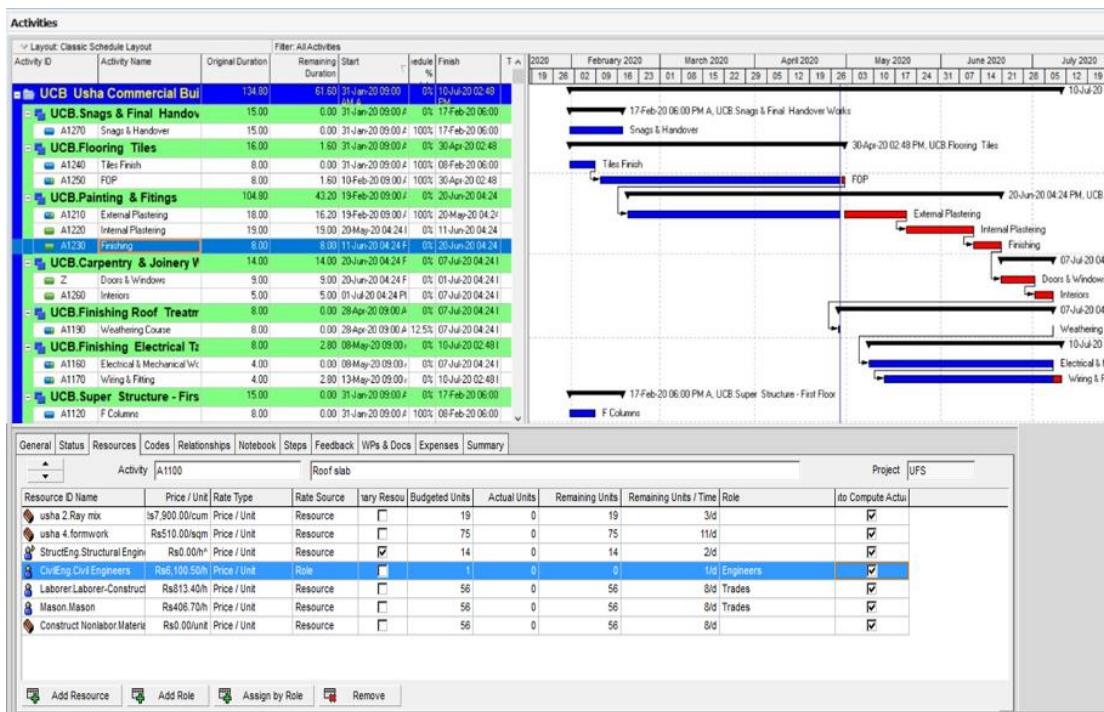


Figure 4. Resource utilization details of a randomly selected activity (Finishing).

3.4. Optimization of resources

Resources for construction project activities are limited in the real-life world. So, resource optimization is very important to avoid waste and shortage of resources on a construction project. The resource usage profile is always inspected for the proper updates on resource availability according to its schedule. A sample resource usage chart is provided in Figure 5, where the ray mix is allocated for each day as per the schedule against the maximum units available per unit of time. The black line represents the maximum limit. Hence, the optimized resource should lie within the limit.

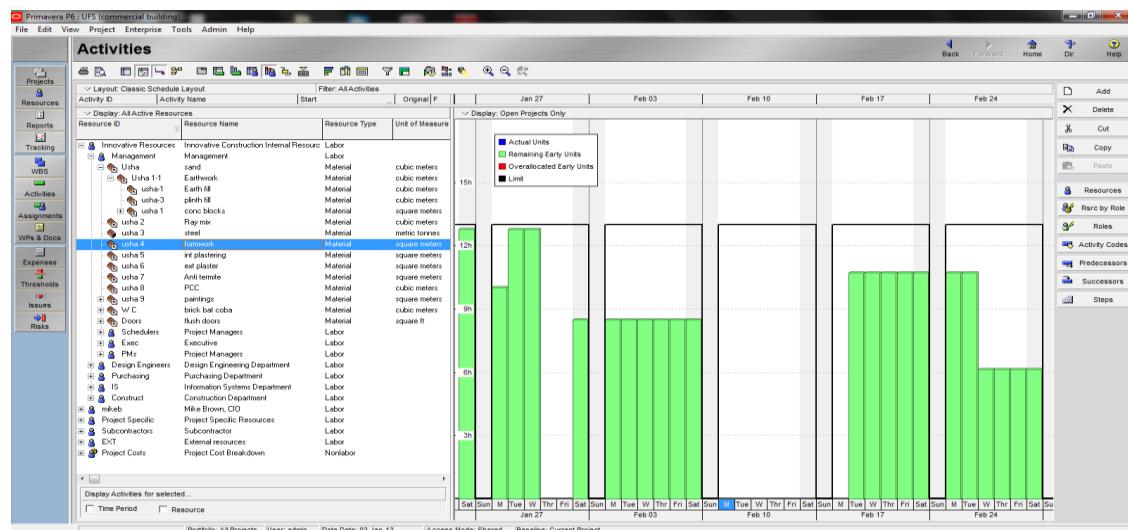


Figure 5. Activities list along with the date & duration of one particular resource.

3.5. Resource leveling

Resource leveling attempts to reduce the sharp variations in the resource demand histogram while maintaining the original project duration. In this project, few resources were over-allocated due to unavoidable circumstances like a delay of supply, weather conditions, etc., which extended the need for the reallocation of the resources without delaying the duration of the project. ‘Level resource’ is a tool in Primavera that is used to reallocate the resources along with the scheduling of activities giving a 25% error range [9]. Figures 6,7, illustrate the scenario for ray mix concrete when there was a shortage in the supply due to the wrong approximation in the project quotation.

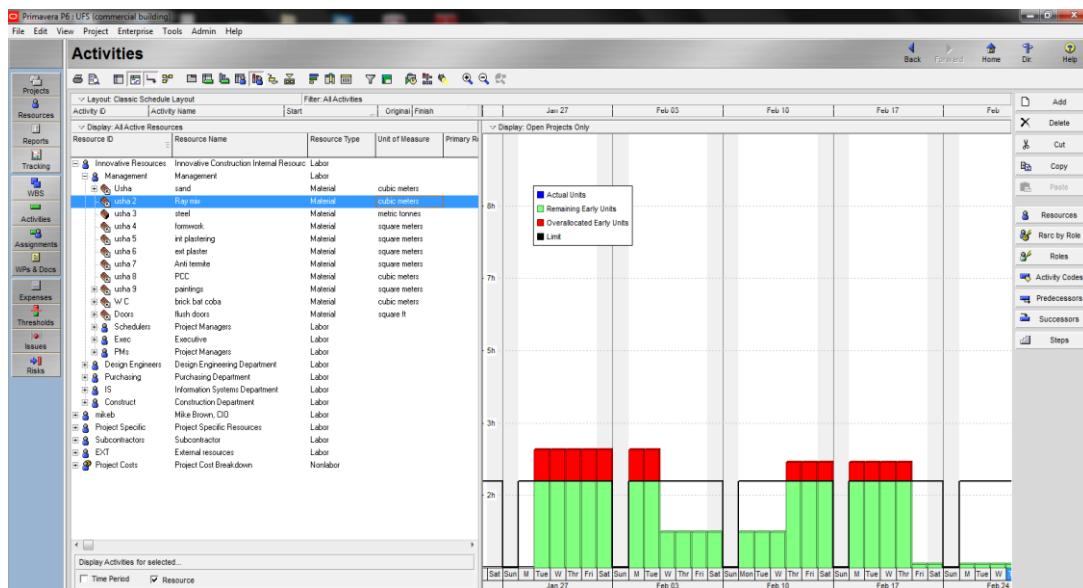


Figure 6. Allocations of resources due to wrong quotation.

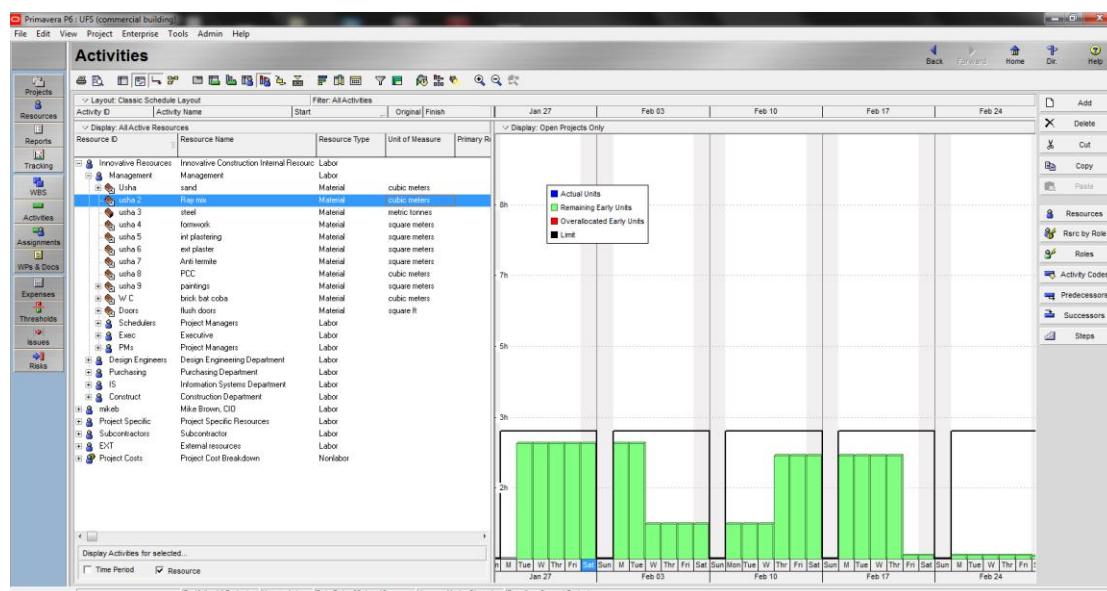


Figure 7. Allocations after resource-leveling.

3.6. Project monitoring and control

Monitoring and controlling are performed during the project execution to identify problems promptly and to take corrective actions to avoid risks in the project performance. The monitoring and control process helps in providing feedback between the various project phases to implement preventive actions to keep the project on track, on time, and within the budget limit time[11].

In this project, the project is tracked for the schedule-based tasks and the corresponding resource availability. The tracking can be done even away from the site using a special web options feature in the Primavera software. The resource assignment for each day of the scheduled activity is fixed, and the task progress is monitored and controlled using the Primavera on a daily basis which is presented in Figure 8.

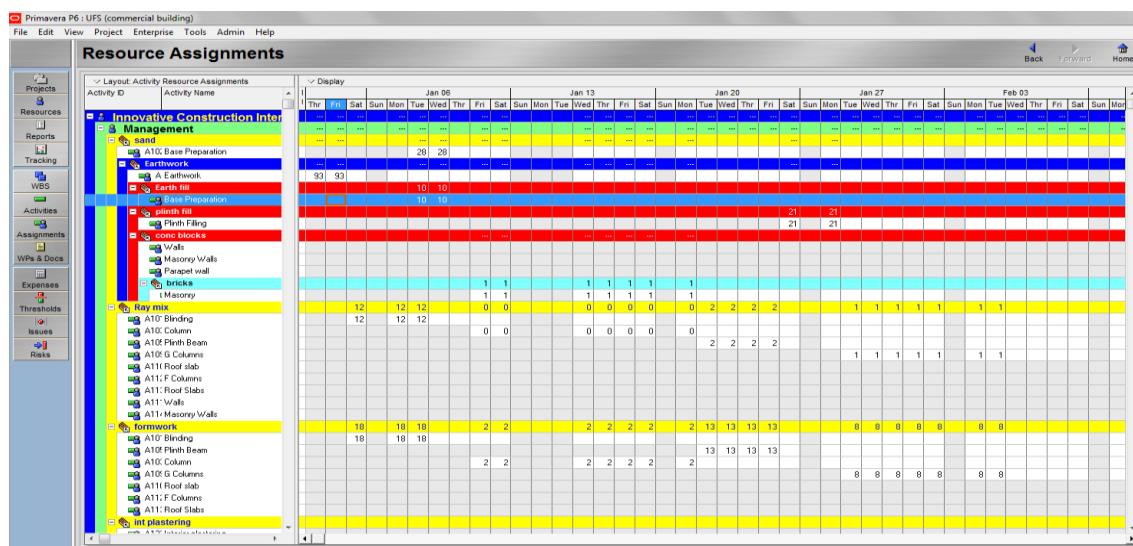


Figure 8. Resource assignments for each day as per schedule.

4. Conclusion

This study mainly focuses on the overall scheduling and planning of the commercial building using Primavera software and analyzing the speed of construction activities compared to the traditional ways. This modern method helps us to adopt minimal requirements in order to achieve an efficient urban built environment. Primavera P6 is an advanced project management tool that helps in the completion of the project within the planned duration and the budget over the traditional methods of planning and management.

This enables project managers, engineers, quantity surveyors, and other associated professionals to have instant access to all the project information they require instantly. Construction companies that are handling multi projects can use this software effectively and efficiently for successful completion. Even though the software is expensive initially, it can be used in a wide range of companies involving repetitive projects. Team members can easily check and monitor the progress of a project when the client or the person in charge is away from the workplace.

Primavera is used widely in the rescheduling of the project so that the resources are effectively used without any delay according to the schedule. From the above observations made on the site, it is been noticed that the entire work managed to be completed (21–07–20) on time with a delay of 21 d

due to the local Covid-19 lockdown. However, the cost of the project is not affected economically and is completed within the planned cost of Rs 4.15 crores (\$5, 58,356). In spite of the lockdown, the project is achieved within the time and budget frame due to the availability of resources & manpower along with the Primavera rescheduling technique; in which work hours are increased without affecting the next day's scheduled activities.

This was the result of using Primavera software which envisages the start of the successor activities depending upon the defined relationships. Besides, the Primavera software aids in reducing 2–3% of the overall cost of the traditional project by reducing the resources based on the slack time. Finally, the project which uses Primavera project management software right from the initiation stages shows more success rate and transparency compared to the other traditional ways of planning and management. The decision-making process of urban built environment quality in construction delivers sustainable growth for future cities.

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Conflict of interest

There is no conflict of interest between the authors.

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