

# Planning, Scheduling, and Optimization of Labor Resources in the construction of Residential Apartment using Primavera P6 software

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**Abstract** - In past decades the construction field has witnessed tremendous changes, updates and grown to new level of dimensions as per customer's desire. Software application is the effective solution for completing Projects as per client's requirements within Baseline Schedule. In this study Primavera P6 software package has been used along with Critical Path Method for Planning and Scheduling of each and every activity till the end of the project. In order to cope up the Problem of lack of Required Labor Resources at required time period in near future, Optimization of Labor Resources is being carried out in the Beginning of project. By the use of Labor Resource Levelling, Smoothing and 1.25 Overtime Working factor technique, the Total Planned Baseline Project Duration changes from 935 Days to 1011 Days, remains constant at 935 Days and got reduced from 935 Days to 748 Days respectively with no increase in Total Labor Units, which in turn results in the proper utilization of available Labor Resources there by Completing Project as per customer desire, and within Baseline Project Duration.

**Key Words:** Planning, Scheduling, Primavera P6, Labor Resource Levelling, Labor Resource Smoothing and 1.25 Overtime Working Factor technique.

## 1. INTRODUCTION

In past decades after the independence our country has witnessed tremendous growth in both the economy and construction industry. The construction is a process involving numerous activities in a sequential manner with number of risks involved till the successful termination of the project. Project management is very important aspect of project from the planning stage till the successful completion of the project within the budgeted cost and planned schedule. In order to avoid or to reduce the number of risks involved very clear, proper, precise, deep planning and scheduling is to be done to complete the project within time frame and cost with minimum or very less constraints during project execution period for smooth and continuous run of sequence of activities. Starting from small to the very large projects it becomes very much necessary to manage all the activities from the start till the closure by a personal such as managers but it becomes impossible to manage properly by keeping concentrated on each and every thing by himself manually that has to be done and monitored. So various project management software's such as Microsoft project

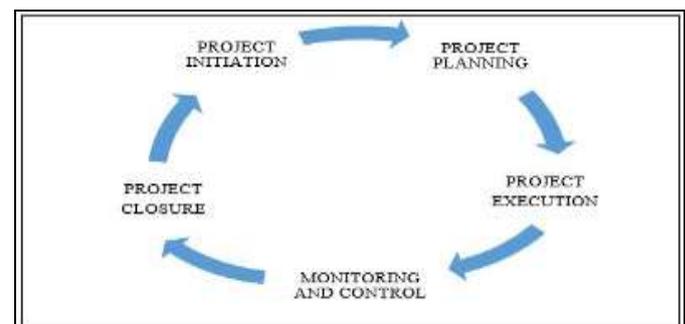
and primavera are being developed to manage the project from planning, scheduling, optimization, tracking till the successful closure of the project is completed.

### 1.1 Project

Project is a sequential work flow of related predefined activities which when carried on the order results in a desired product on successful completion with the consumption of available resources.

### 1.2 Project Management

The project management involves various processes which helps in successful completion of the well-defined activities in a hierarchical manner to achieve desired outcomes within the planned schedule and budgeted cost. Efficient Project management involves following processes in the orderly manner from initiation, planning, scheduling, execution, monitoring & controlling, till the closure of the project is complete. The Project Management processes is as shown in Flowchart 1.



**Flowchart-1: Shows Project Management processes.**

### 1.3 Planning of project

Planning is one of the very important stage in the project life cycle and it forms the back bone of project management. The planning should meet the requirements of Scope of the project by making use of the information collected and developed.

There are no of core processes in the way which are being carried out normally done before start of project, they are Scope Planning, Scope Definition, Strategic Plans, Logistic

Plan, Activity Definition, Activity Sequencing, Activity Duration Estimating, Schedule Development, Resource Planning, Cost Estimating, Cost Budgeting, Project Plan Development, Quality Planning, Organizational Planning, Staff Acquisition, Communication Planning, Risk Identification, Risk Quantification, Risk Response Development, Procurement Planning, Solicitation Planning etc.

#### 1.4 Scheduling of Project

Scheduling of Project involves locating and fitting the final work plan accordingly onto a time frame. It indicates 'what to do' and 'when to do aspects'. A well planned schedule is the one which ensures all the components of the project are completed on time and on-budget. While preparing a schedule for the project well experienced persons having a high experience in the actual field execution is to be hired for preparing it. In preparing a well-defined schedule involves mainly two things, determining how long each activity takes to complete and determining what and who is responsible for finishing them.

#### 1.5 Optimization of Labor Resources

Resource optimization is the use of set of processes and methods used to match the available resources (human, materials, plant and machinery) with the needs of the organization to achieve the established goals and objectives. Here the available resources are fully utilized with maximum productivity. The Optimization of labor is very much needed for work balancing. It helps in capacity utilization to complete the project within the schedule of the project. There are various methods of Labor Resource Optimization, they are as follows,

##### 1.5.1 Labor Resource Leveling

The Labor Resource Leveling is one of the techniques of optimization of labor resources. In this the schedule calculation involves start and finish dates that are adjusted based on resources constraints so that the overall project duration is increased on completion.

##### 1.5.2 Resource Smoothing

The labor resource smoothing is one of the methods of optimization of labor resources. In this the schedule calculation involves utilizing float or increasing or decreasing the resources required for each specific activity, such that any peaks and troughs of resource usage are smoothed out. This technique has no effect on the overall duration. This type of scheduling is called as time limited resource scheduling.

#### 1.6 About Primavera

Primavera is known as ENTERPRISE PROJECT PORTFOLIO MANAGEMENT (EPPM) Software. This software at first developed by a company known as **Primavera Systems, Inc.** which was a private company which provides Project Portfolio Management (PPM) software to the organization's involving identification, prioritizing, selecting investments plans, managing, monitoring, tracking and controlling of projects portfolios of different sizes. Primavera P6 is the later version after of P3 and Sure-Trek and is designed to provide a Single solution for managing or controlling Projects has been used in this project. The Fig-1: represents Oracle Primavera P6 software Logo.



Fig-1: Oracle Primavera P6 software Logo.

## 2. LITERATURE SURVEY

**Raj Saran et al (2016) [1]**, carried out a study on "Planning and Scheduling of a Two storey building using Primavera P6". In this paper the author has explained about step by step process to be followed for proper Planning and Scheduling in Primavera P6 software. Planning and Scheduling is one of the important management processes which plays an important role in the Project success. As proper Planning is very much necessary for accurate Scheduling involving defining of work activities, finding out general sequence, various construction methods, Time frame and assigning Resources and responsibilities. In this case study necessary processes starting from Enterprise Project Structure, OBS, Project Calendar, WBS, Activities, Precedence with relationships, Schedule, Baseline till the plan update has been explained.

Nowadays huge Projects involves complexities, proper care to be taken to avoid complexity in Planning, and Scheduling which necessitates the use of Project Management tools such as Microsoft Project and Primavera software's for their easy in using with high details helps carrying out of Project continuously without any obstructions till the closure of the Project is reached.

**Rhuta J and Prof. V Z Patil (2015) [2]**, carried out a study on "Resource Scheduling of Construction Project: Case Study". As the construction Projects are subjected to a Risks due to number of reasons during its period from Initiation

till Closure. Thus the management of the Project activities from Planning, Scheduling, Coordinating the Resources as per the activity requirement is done through Project Management techniques such as Critical Path Method (CPM) and Project Evaluation and Review Techniques (PERT) which in turn helps in the efficient and economic use of Resources. He states that Project delays occur due to inadequate supply of required Resources. The preparation of accurate and workable Plan for the large complex Projects becomes very difficult without the use of them. The use of Project Management Packages Such as Microsoft Project, and Primavera in the construction industry helps in resolving Resource conflicts.

In this research, Resource constrained Project Schedule is being prepared. It has been found from this is that after Resource Levelling of Project is done, the Project duration increased to 781.5 days (10.38%) as compared with 708 days which is the actual Planned duration and total increase in Project cost to Rs. 136,850,237 (0.94%) as compared to budgeted value of Rs. 135, 570,600.

**Vignesh (2017) [3]**, carried out a study on "Resource Optimization of Construction Projects using Primavera P6". As the construction Projects are complex & unique in nature with risks, difficulties, and uncertainties posed related to Resources and Cost till the completion of project, He assumes that the project success is very much dependent on the project management by efficiently utilization of Manpower, Materials, Machineries, Money and Time. Before starting any project Accurate and Workable Plan is to be prepared with care.

In scheduling the project, the manager schedules activities to be done in parallel for the purpose of to time constraint, this necessitates use of same resources by two parallel activities which are limited. In this paper he conducted study to avoid such conflicts by the use of Resource Balancing Techniques. Here at first Resource Smoothing is done and later Resource Levelling is adopted to study the effect on duration and cost of the entire Project. In his study, he first carried out Resource Smoothing and found out that the overall cost reduction due to labor optimization is 1.02% and decrease in the duration is by 50 days as compared with tender Schedule. In later case Resource Levelling is being carried out, with the overall Cost reduction is 2.49% with the increased duration by 67 days as compared to the Resource Smoothing and shot by 17 days as compared with tender Schedule.

**S K Nagaraju et al (2015) [4]**, carried out a study on "Resource Management in Construction Projects – a Case Study". In his study, he stated that construction Project refers to a high stake endeavor aiming at time bound predetermined performance objectives. He has carried out study in two phases, in the first phase, with the help of Primavera software Project Schedule for various activities for the construction of commercial buildings was prepared.

Later requirements of Resources were attributed to activities based on the standard Schedule Rates (CPWD). These required data have been collected from the detailed drawings and present site conditions.

In the second phase, they carried out Resource Constrained Analysis by Resource Levelling for possible various activities decreasing the Labor Resources in numbers with increased duration for studying time-cost implications. Here in his research, he observed that for percentage decrease in Resource-Constraints, there is increased duration for Resources namely masons, bar bender and unskilled helpers by 19.7%, 12.7% and 18.28% respectively. But it is observed that there is no increase in duration for painters as it is an independent activity in total project. This resulted in increased total project cost of 1.684% as due to increased duration of 18.23% resulted in increased indirect cost of Project.

### 3. PROJECT DETAILS AND METHODOLOGY

#### 3.1 Project Details

Pelican Grove is a Residential Apartment consisting of 2 Basement with 7 floors and one Terrace Floor with total of 14 apartments with each floor consists of 2 Flats with 4 BHK in each apartment, situated in an enchanted piece of land sits on the banks of Jakkur Lake is being considered in our study. On northern side of project site there are number of private properties such as Elegant Embassy North apartments, open lands exist, on southern side a beautiful farm land exists with greeneries along with railway track that connects yelahanka railway station to KSR Bangalore railway station, on eastern sides a beautiful Jakkur Lake exists which aspires with wonderful views and environment, on western side private house dwellings exists. The Project also includes several amenities such as swimming pools, Spas, Forest Yoga Deck, Jogging Track, Multi-Purpose Official-size court, Cricket nets, and others include Rainwater harvesting, Sewage treatment plant, greater than 90% open space and Zero Water and Sewage discharge facilities are put together in a Project to make it unique and different from others.

#### 3.2 Objectives of the Study

The following are the objectives of my study,

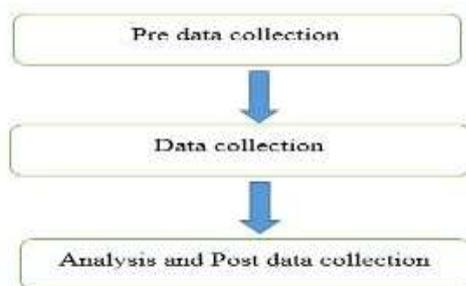
- To find out, prioritize and arrange each and every activity of the project in a sequential manner with respect to the time frame and resources to complete within the specified budget.
- To identify all the risks and constraints to project work flow that may has worst effect on the whole project.
- To Schedule the Project based on the Planned activities along with Resources requirement with a time frame.

- To avoid the Labor Resource conflicts in later period of time & to obtain the smooth Labor Resource usage profiles with maximum usage & minimum wastage and to compare the Project Baseline Schedule and Total Cost of Labor Resources both before and after the Optimization of Labor Resources.

### 3.3 Study work Methodology

The Research Methodology is the systematic way in which each and every activity is being carried out in a structured and orderly manner. The methodology which is being adopted in this project is taken from Literature Survey and by referring from various knowledge sources and represented in manner as shown in Flowchart-2. This involves the following stages,

- 1) Pre data collection.
- 2) Data collection.
- 3) Post data collection.



**Flowchart-2: Shows Project Methodology Flow table.**

#### 3.3.1 Pre Data collection

In this the collection of data's in the form of information from various knowledge areas, Literature survey, peoples review etc., is being carried out. Also the Objectives setting, Problems Statement done based on the choosen research area. The data collected is being documented, stored properly and some case studies is being carried out in the research area so that no problems, Risks should come during the work execution process. In this stage based on the data's collected initial feasibility study, planning in terms of material, machinery, equipment's and labor required is being identified and calculated. Also Land Survey, Soil Investigation, environmental impact assessment is being carried out, reports are being prepared and documented in the format.

#### 3.3.2 Data collection

In this stage the collection of data during actual execution of various works form initial stage till end is being done from the daily site visits. The data collected includes the following,

- Daily Progress Report and Monthly Progress
- Reports.

- Labor Productivity.
- Activities with their Planned durations for
- comparison.

#### 3.3.3 Post Data collection

In this stage the collected data from Pre data Collection and data collection stage are entered into Software Package Primavera P6 and analysis is being carried out, updating, Optimization, tracking of the Project is being carried out and Reports & Results are generated and studied carefully and number of conversations are being carried out with the organization for the selection of suitable procedure for Planning, Scheduling, tracking and software to be used in next Project is being done.

### 4. ANALYSIS USING PRIMAVERA

Once the collection of pre requisite data is being done from different field areas, next step is to Prepare a Schedule from a Planned Activities and carry out Optimization of Labor Resources by using Primavera P6.

The step by step procedure for carrying Planning, Scheduling and Optimization of Labor Resources by using Primavera P6 is as follows,

- 1) Create an Enterprise Project Structure (EPS).
- 2) Create an Organizational Breakdown Structure (OBS).
- 3) Create a New Project.
- 4) Create a Calendar.
- 5) Add Units of measure, Industry selection and Roles.
- 6) Setting User Preferences.
- 7) Create Work Breakdown Structure (WBS).
- 8) Create Activities for a Project with Time Period.
- 9) Assign Logic Relationships between Activities.
- 10) Assign Resources, Roles and Expenses.
- 11) Scheduling of Project.
- 12) Set Baselines.
- 13) Updating of Schedule.
- 14) Optimization of Labor Resources.

### 5. RESULTS AND DISCUSSIONS

#### 5.1 Baseline Schedule

In this Project the Residential Apartment having single tower is being considered for study. By considering all the things like Total Quantity of work, Productivity of different labor sections, Availability of both material & Labor Resources, Field conditions, methods adopted for construction, Actual Risks that is going to come during execution etc., the Schedule is being prepared by using Primavera P6 consists of path in which each and every activity have to be proceeded step by step with time in the form of dates for its completion. The Schedule is a final product which is an amalgamation of WBS with sequence of activities with their logical relationships, quantity of Resources within the time

frame. The Schedule which is being prepared is compatible with actual field execution and it had been in such that any further changes like updating's can be done in this schedule. The details of Project Schedule which is being prepared is as shown below in Table-1,

The Project Managers should check the Schedule in this process so that all the data that entered and it is being displayed are exact same as required and also he should continuously check the progress of work Schedule in field and make any changes to Project Schedule prepared to get daily updated.

**Table-1: Project Baseline Schedule results.**

WBS Name	Original Duration	Remaining Duration	Start Date	Finish Date	Baseline start	Baseline Finish	Duration % complete
PELICAN GROVE	935	711	17 Aug 2018	11 Aug 2021	17 Aug 2018	11 Aug 2021	23.75
a.Preliminary Works.	62	0	17 Aug 2018	27 Oct 2018	17 Aug 2018	27 Oct 2018	100
b.Excavation.	45	0	29 Oct 2018	28 Dec 2018	29 Oct 2018	28 Dec 2018	100
c.Sub-structure.	159	70	31 Dec 18	8 Aug 2019	31 Dec 18	8 Aug 2019	66
d.Super-structure	353	353	6 May 2019	19 Jun 2020	6 May 2019	19 Jun 2020	0
e.Finishes	398	398	3 Feb 2020	11 Aug 2021	3 Feb 2020	11 Aug 2021	0

## 5.2 Optimization of Labor Resources

The optimization of Labor Resources involves effective utilization of Labor Resources when there is shortage of required Labor Resources, also when there are undesirable sudden fluctuations in required Labor Resources Profile. So in order to solve these problems the following two techniques has been used in my Project study.

### 5.2.1 Resource Levelling

Here at first the basic Schedule of Project is being considered later on Labor Resource Levelling is being done. Here basically the Bar-benders, Carpenters, Masons and their Helpers is being selected for this process. Once the Resource Levelling is done, the Original Planned Baseline Project Duration changes from 935 Days to 1011 Days causing delays to the Project of about 76 Days which ends on 8 November 2021. The main reason for causing delay to original Baseline Planned Project Duration lies in the fact that making Activities to happen on that period when there is enough sufficient required Labor Resources is available to perform the prescribed Activities in prescribed manner.

Hence one can't see there is increase in the Labor Resource units occurring rather causing increase in duration of all the Activities which has less Resources available than the required planned Labor Resources in selected Labor Resources. Due to this main reason, the Labor Resource usage profile for all Bar-benders, Carpenters, Mason and Helpers changes to a new dimensions occupied in different time scale. The details of the Baseline basic Schedule after Project Resource Levelling are tabulated below in Table-2,

**Table-2: Labor Resource Levelling results for Basic Schedule.**

SL. NO.	DESCRIPTION	BEFORE LABOR RESOURCE LEVELLING	AFTER LABOR RESOURCE LEVELLING
01.	Start Date	17 Aug 2018	17 Aug 2018
02.	Finish Date	11 Aug 2021	8 Nov 2021
03.	Baseline Start Date	17 Aug 2018	17 Aug 2018
04.	Baseline Finish Date	11 Aug 2021	9 Nov 2021
05.	Original Duration	935	1012
06.	Remaining Duration	711	787
07.	Labor Units (B, C, & M)	255904 Hours	255904 Hours
08.	Physical % Complete	7.27 %	7.27 %
09.	Schedule % Complete	5.19 %	5.19 %
10.	Duration % Complete	23.96 %	22.14 %

Based on the above results it is seen that after Labor Resource Levelling process is done, the Total Project Original Duration increases from 935 Days to 1012 Days with no increase in the Labor Units. Also it is seen that Duration percent complete decreases from 23.96% to 22.14% of Original Duration due to Resource Levelling process carried out on selected less available Resources such as Bar-benders, Carpenters, and Mason.



**Fig-2: Showing Schedule after Resource Levelling.**

At initial stage if Resource levelling is done which may cause extension of Project Duration so that at any certain stage the Construction work is not hindered and no further complications such as imposing of fines, making workers to perform stressed over work time to complete work on time etc., can be avoided. The Fig-2 represents Schedule after Resource Levelling.

5.2.2 Resource Smoothing

Here at first the basic Schedule of Project is being considered later on Labor Resource Smoothing is being done. Here basically the Bar-benders, Carpenters, Masons and their Helpers is being selected for this process. Due to Labor Resource Smoothing process the Original Planned Baseline Project Duration remains unchanged in 935 Days and also the Total Labor Units remained unchanged. But Selective Labor Resource Usage profile changed after this process to fit within a free float duration with Over-allocation of selected Labor Resources to get Smooth Labor Usage Profile for Bar-benders, Carpenters, and Masons. The details of basic Schedule after Labor Resource Smoothing is as shown below in Table-3,

Table-3: Labor Resource Smoothing results for Basic Schedule.

SL. NO.	DESCRIPTION	BEFORE LABOR RESOURCE SMOOTHING	AFTER LABOR RESOURCE SMOOTHING
01.	Start Date	17 Aug 2018	17 Aug 2018
02.	Finish Date	11 Aug 2021	11 Aug 2021
03.	Baseline Start Date	17 Aug 2018	17 Aug 2018
04.	Baseline Finish Date	11 Aug 2021	11 Aug 2021
05.	Original Duration	935	935
06.	Remaining Duration	711	711
07.	Labor Units (B, C, & M)	255904 Hours	255904 Hours
08.	Physical % Complete	7.27 %	7.27 %
09.	Schedule % Complete	5.19 %	5.19 %
10.	Duration % Complete	23.96 %	23.96 %

Based on the above results it is seen that after Carrying out Labor Resource Smoothing process, the Total Project Original Duration remained unchanged at 935 Days with no increase in the Labor Units with the Resource Smoothing process carried out on selected less available Resources such as Bar-benders, Carpenters, and Mason. Also it is seen that Duration percent complete remained constant at 23.96% of Original Duration. In this study we found that Final Smooth Labor Usage Profile can be obtained by making variations in the Maximum percent to over-allocate Labor Resources. This causes a non critical activity to be delayed within the Total Float of it, causes non-critical Activities to be delayed in finishing but within Baseline Finish Date of Project. By this the manager can avoid any acute shortage of Selected Labor Resources that would be occurring due to sudden fluctuations in Labors in Labor Resource profile of required Labors in practical considerations keeping in mind whenever we require labor as per Labor usage profile with sudden fluctuations within a week and Months, the required amount of required Labors will not be available whenever it is required that may cause Project Finish Date to be delayed.

Last option left is the maximizing the use of available Labor Resources with Minimum amount of wastage. This involves making less available Labor Resources such as Bar-benders, Carpenters and Masons to work overtime so that total working hours per day changes from 8h/d to 10h/d the expected total duration of Project is 748 Days assuming that no shortage of Labor Resources occurs but during actual execution the project may face no of hurdles such as Labor Resource shortage, due to heavy rainfall, non-delivery of material Resources on time, due to no proper management of Labor Resources etc. By making Labor Resources to work extra 2h/d it is possible to complete Project within Baseline Schedule duration of 935 Days taking into account various factors that will cause Project to be delayed.

The Fig-3 and Fig-4 represents Schedule after Resource Smoothing and Basic Schedule after making Labor Resources to Work overtime.



Fig-3: Showing Schedule after Resource Smoothing.



Fig-4: Showing Basic Schedule after making Labor Resources to Work Overtime.

## 6. CONCLUSION AND FURTHER SCOPE

### 6.1 Conclusions

Based on the work performed in Primavera P6 software. The following are the major outcomes of this study,

- The initial detailed Planning helped in the preparation of Baseline Project Schedule in which Projects starts on 17 Aug 2018 and Finish on 11 Aug 2021 with the total duration of 935 Days taking into consideration field actuals, Risk factors etc., by using Primavera P6.
- After carrying out Labor Resource Levelling process in Primavera P6 for Bar-benders, Carpenters, and Masons, the Schedule Duration increases from 935 Days to 1012 Days with no increase in the Total Labor Units of selected Labor Resources.
- Once the Labor Resource Smoothing process is being carried out in Primavera P6 for Bar-benders, Carpenters, and Masons, it is observed that Schedule Duration remains constant at 935 Days with no increase in the Total Labor Units of selected Labor Resources. The Smooth Labor Resource Usage profile of selected Labor Resources such as Bar-benders, Carpenters, and Masons having Maximum percent to Over-allocate set to 25% is being selected as final Labor Resource Usage profile.
- By making workers to work 10h/d with considerations such as Labor Resource shortage, due to heavy rainfall, non-delivery of material Resources on time, due to no proper management of Labor Resources etc. that may cause Project to be Delayed, so that Project can be completed within Baseline Schedule of 935 Days. Total Cost of selected Labors Resources such as Bar-benders, Carpenters, and Masons in both before and after the Labor Resource Levelling and Labor Resource Smoothing process remained same at Rs. 2,05,43,280.
- By using Primavera P6 software preparation of Detailed Schedule, Updating and Optimization of Labor Resource are being carried out successfully.

### 6.2 Further Scope of Work

- By the use of Optimization of Material Resources, Material resource Management and Labor Resource Management the level of wasting of both the Material and Labor Resource can be reduced to low level as possible in near future.
- The Risk Management feature can be implemented in Primavera P6 so that no other separate software packages are being used to identify Risks involved in this Project.

- The effect of Decision Making on the amount of both Material & Labor Resources waste generation at different levels of Project is to be studied.

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