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A Comparative Study of Time and Cost Optimization in Project Management: Primavera P6 & Linear Programming with Lingo Solver

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Abstract - In an effort to boost efficiency and reduce costs, computer-based solutions have become more popular for project management. Although Primavera P6 and other traditional tools have proved essential for project planning and control, difficulties still arise with complicated projects. An innovative approach is provided by the development of mathematical optimization techniques, especially Linear Programming (LP) with programmes like Lingo Solver. The purpose of this study is to compare the time and cost optimization of Primavera P6 and Lingo Solver's LP. The goals are to analyse the advantages and disadvantages, evaluate the effectiveness and adaptability, and offer useful information to decision-makers.
Application of Lingo Solver's LP is found to significantly reduce project duration, with a significant impact on cost trends. On the other hand, Primavera P6 shows that project duration can be reduced while maintaining the same level of cost. The study highlights how the duration of the project, additional indirect expenses, and costs interplay dynamically throughout the duration of the project. This research provides useful insights to the continuing discussion on project management methodologies by bridging the gap between conventional project management tools and advanced optimization techniques. This will help decision-makers overcome the complexities of project optimization for optimal results in practical applications.

***Key Words*:** Optimization, Construction project, Linear programming, Primavera p6, Lingo, Project management, Mathematical model, Time-cost trade-off.

1. INTRODUCTION

1.1. BACKGROUND OF STUDY

Over the years, there has been a significant evolution in project management, with a focus on computer-based solutions to increase productivity, reduce costs, and ensure project execution. The utilisation of traditional project management software, such as Primavera P6, has been essential in simplifying project planning, scheduling, and control. This software provides functionalities including resource allocation, Gantt charts, and critical path analysis.

However, problems with cost minimization and resource allocation continue to arise as projects become more complicated. Project management has taken on a new dimension with the introduction of mathematical optimization techniques, specifically Linear Programming (LP) with Lingo Solver. As a methodical approach to cost-effectiveness and resource optimization, linear programming is a mathematical optimization technique that looks for the most optimal solution using mathematical modelling.

The necessity to investigate and comprehend the benefits and drawbacks of both conventional and mathematical optimization approaches is what prompted this comparative study. Organisations must choose which tool to use depending on the demands of the project, available funds, and the difficulty of the work. This research aims to contribute to the ongoing discourse in project management by offering empirical insights into the cost optimization capabilities of Primavera P6 and Linear Programming with Lingo Solver.

1.2. EVOLUTION OF PROJECT MANAGEMENT SOFTWARE

Project management has evolved throughout the years from manual techniques to computer-based solutions. Project planning and execution now require the use of software tools like Primavera P6, which offers functions like Gantt charts, resource allocation, and critical path analysis. These tools are designed to facilitate decision-making, increase teamwork, and expedite the management process.

1.3. CHALLENGES FACED IN TRADITIONAL APPROACH

1. The accuracy needed for complex resource allocation and cost optimization may be lacking in traditional project management software.
2. As projects get more complicated, more complex project structures may be difficult for standard tools to manage and OPTIMIZE.
3. In project contexts that are changing quickly, it may be difficult for traditional methods to react in real time and modify resource allocations appropriately.

4. Conventional approaches frequently depend on heuristics and general guidelines, which may result in less-than-ideal results in terms of cost and resource usage.

2. LITERATURE REVIEW

The literature review that follows includes some theoretical and analytical research that has been done in this field.

[1] Patel (2019) researched on ‘Optimization in construction management’, It covers a range of topics related to optimization in the construction sector. In order to achieve the intended output or to maximize profit margins under specific input conditions, optimization entails choosing the optimal combination of inputs. The paper emphasizes the need for thorough planning and application of optimization strategies. The article suggests using digital platforms for communication, creating a proper hierarchy within project teams, resource optimization in management, and carefully considering cost-benefit analysis before implementing schedule compression techniques to effectively optimize construction projects.

[2] Shashaa D. (2021) conducted research on, ‘Analysis of effective optimization of construction technology in municipal engineering construction projects’ Municipal engineering project building is becoming more challenging and complex, and it significantly affects urban people’ quality of life. In addition to promoting sustainable growth and improving the national economy, construction technology optimization can have a favourable effect on the effectiveness and quality of construction. In conclusion, construction technique has a direct impact on the quality of municipal engineering construction projects. To strengthen market competitiveness, businesses should pay more attention to construction technology optimization and continuously improve construction technology management.

[3] Ravande Kishor studied, ‘Optimization of construction projects scheduling using primavera and genetic algorithm’, The article highlights the value of managing resources in building projects and how genetic algorithms (GA) can be used as a global search method to address the scheduling issue associated with resource constraints. The study contrasts the outcomes from the GA technique utilizing Evolver software with those from the Primavera software, demonstrating that the GA strategy offers optimized results with a length of 317 days. For resource constrained project scheduling, the use of a genetic algorithm model has produced optimized results at lower prices.

[4] The efficiency of the method was demonstrated by an actual project that was solved using this optimization software, which saw a 6.4 percent decrease in costs and a month’s reduction in the overall project duration.

[5] Zolekar performed a study on ‘Cost optimization of construction projects by using advance methods and advanced materials’ conducted research on construction project cost optimization. They investigated cutting-edge techniques like prefabrication and Building Information Modelling (BIM), as well as the usage of cutting-edge materials. Their research intended to lower costs and boost construction’s cost effectiveness. In conclusion, research concentrated on the cost optimization of construction projects through the employment of cutting-edge techniques and materials. Their research focused on life cycle costs while examining the advantages of BIM, prefabricated components, and novel materials.

3. OBJECTIVE OF THIS STUDY

1. Compare and contrast project management time & cost optimization techniques.
2. Give close attention to Lingo Solver's linear programming and Primavera P6.
3. Examine the advantages and disadvantages of each strategy.
4. Assess efficiency, precision, and flexibility in a range of project situations.
5. Offer decision-makers and project managers practical information.
6. Construct a bridge between sophisticated optimization tools and conventional software.
7. Add to a more complex comprehension of the usefulness and relevance of real-world application.

4. METHODOLOGY

1. **Review of Literature:** Performed a thorough analysis of the body of knowledge regarding cost optimization in project management, including studies on Primavera P6, linear programming, and the Lingo Solver. Wrote a summary of pertinent techniques and observations.

2. **Choosing a Case Study**: Chose a wide range of real-world project case studies that illustrate different project difficulties and industries which are appropriate for analysis using Lingo Solver for linear programming and Primavera P6.

3. **Gathering of Data:** Collected pertinent information for every case study that has been chosen, such as project schedules, resource allotments, financial restrictions, and actual expenses

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4. **Creating Models for Linear Programming:** Created the linear programming model using the gathered using LINGO solver and depicted situations for cost optimization, defining goal functions and restrictions.

5. **Primavera P6 Analysis:** Use Primavera P6 to simulate project schedules and resource allocations for the chosen case studies. Recording of important information such as critical path, resource utilisation, and project completion times is done.

6. **Performance Metrics:** Created a set of performance metrics, such as cost efficiency, resource utilisation, and schedule adherence, to evaluate both Primavera P6 and Linear Programming with Lingo Solver quantitatively.

7. **Comparative Analysis:** Examined the results of the Primavera P6 simulations and Lingo Solver solutions for case study. Examined the advantages and disadvantages of each method in terms of cost optimization, resource utilisation, and schedule efficiency.

8. **Results Synthesis:** Combine the quantitative and qualitative data to derive general conclusions about how well Primavera P6 and Linear Programming with Lingo Solver perform in comparison when it comes to project management cost optimization.

5. PROBLEM STATEMENT

In project management, achieving optimal cost outcomes is a constant difficulty. The purpose of this study is to compare the efficiency of two time & cost optimization approaches: Primavera P6 and Linear Programming using Lingo Solver. In order to help project managers select the best strategy for their projects, the purpose is to offer insight about their effectiveness, accuracy, and flexibility. The main query is: In a variety of project scenarios, which technique provides the best value in terms of both time and cost?

6. PROBLEM FORMULATION FOR LIVE VILLA CONSTRUCTION PROJECT

The project data presented below in fig. 01 & fig. 02 has been procured from the ongoing villa construction project through in-depth discussions with the Project Manager. The main goal is to crash the project's length compared to the original estimated completion time. The following data shows the activity and normal duration and cost required for each activity to be complete.

ACTIVITIES	TASK NAME	DURATION	START	FINISH	COST	CRASH TIME	CRASH COST
	Standard Villa	**531 DAYS**	**22-07-2023**	**30-03-2024**	**1,43,94,629**	**484 days**	**1,43,11,938**
	RCC Works	**42 DAYS**	**22-07-2023**	**25-08-2023**	**14,50,086**	**37 DAYS**	**15,01,955**
	Swimming Pool	**30 days**	**22-07-2023**	**25-08-2023**	**9,08,816**	**26 DAYS**	**9,26,105**
1	Excavation	4 days	22-07-2023	25-07-2023	1,50,000	2.5 days	1,55,250
2	50mm plane in situ binding to bed	3 days	26-07-2023	28-07-2023	47,800	2 days	49,560
3	Reinforcement	10 days	29-07-2023	09-08-2023	4,46,800	8 days	4,50,045
4	Shuttering	12 days	10-08-2023	23-08-2023	9,000	11days	11,250
5	RCC Concrete	2 days	24-08-2023	25-08-2023	2,55,216	2 days	2,60,000
	Water Body Pool	**12 days**	**15-07-2023**	**28-07-2023**	**5,41,270**	**11 DAYS**	**5,75,850**
6	Excavation	2 days	15-07-2023	17-07-2023	90,526	2days	99,350
7	PCC raft	1 day	18-07-2023	18-07-2023	1,01,256	1days	1,06,750
8	Reinforcement	4 days	19-07-2023	22-07-2023	1,52,962	3days	1,56,450
9	Shuttering	4 days	24-07-2023	27-07-2023	5,962	4days	8,050
10	RCC Concrete	1 day	28-07-2023	28-07-2023	1,90,564	1days	2,05,250
	Site works	**489 DAYS**	**29-07-2023**		**1,02,79,566**	**447 days**	**1,01,60,315**
11	**Excavation for foundation**	**20 days**	**29-07-2023**	**19-08-2023**	**2,13,112**	**18 DAYS**	**2,28,400**
12	Shoring & dewatering works	2 days	29-07-2023	30-07-2023	35,560	2days	40,320
13	Site clearnce	5 days	01-08-2023	02-08-2023	20,800	3days	22,580
14	Excavation for foundation	16 days	03-08-2023	19-08-2023	1,56,752	13days	1,65,500
	Anti termite treatment	**10 days**	**20-08-2023**	**30-08-2023**	**23426**	**8 DAYS**	**26,540**
15	Anti termite treatment	10 days	20-08-2023	30-08-2023	23,426	8days	26,540
	Sub structure	**24 days**	**01-09-2023**	**17-09-2023**	**19,78,640**	**19 DAYS**	**20,60,330**
	In situ concrete						
16	Plain poured concrete	3 days	01-09-2023	03-09-2023	6,23,450	3days	6,46,210
17	Reinforced sulphate resistant cement concrete	4 days	03-09-2023	06-09-2023	12,56,740	4days	12,58,750
18	In raft slab	3 day	06-09-2023	08-09-2023	10,256	2days	52,520
19	In column	5 days	08-09-2023	11-09-2023	8,030	3days	26,780
20	In walls	4 days	11-09-2023	14-09-2023	21,070	3days	25,100
21	In ground floor slab	2 days	14-09-2023	15-09-2023	13,870	2days	38,740
22	In staircase	3 days	15-09-2023	17-09-2023	45,224	2days	12,230

Fig -1: Live project data

73	20mm thick Cement and sand plaster to external walls	8 days	11-03-2024	19-03-2024	56,473	6days	60,550
	Finishes						
74	EF 5 - Supply and apply Paint finish Paint - Type P3, to the cement sand plastered walls CP-3 (measured seperately).	7 days	20-03-2024	27-03-2024	42,478	6days	46,550
75	EF 10 - Plaster grooves extra over to the External Plaster	5 days	28-03-2024	02-04-2024	19,784	4days	23,580
	External works	**25 days**	**30-04-2024**	**25-04-2024**	**89,346**	**21 DAYS**	**97,370**
	Boundary walls						
76	Construction of Boundary wall rear & either sides of the plot as per drawings complete including earth works, concrete works and finishes (excluding related MEP works)	15 days	30-04-2024	14-05-2024	56,452	13days	58,620
77	Construction of Boundary wall Front Side as per drawings complete including earth works, concrete works and finishes (excluding related MEP works)	10 days	15-04-2024	25-04-2024	32,894	8 days	38,750
	Additional Window Work	**10 DAYS**	**25-04-2024**	**01-05-2024**	**1,36,252**	**8.5 DAYS**	**1,45,902**
78	Window 1 Kit	1 day	25-04-2024	25-04-2024	38,265	1 day	40,020
79	Window 2	2 days	25-04-2024	26-04-2024	38,265	2 days	40,020
80	Window 3	2 days	26-04-2024	27-04-2024	38,265	1.5 day	40,020
81	Civil work	5 days	28-04-2024	01-05-2024	21,457	4 days	25,842
	Services	**186 DAYS**	**02-04-2024**	**03-07-2024**	**57,66,019**	**180 DAYS**	**57,77,710**
82	Electrical Work	45 days	02-04-2024	15-05-2024	23,66,587	42 days	23,72,600
83	IBMS Work	82 days	10-04-2024	30-07-2024	13,36,944	80 days	13,40,260
84	Plumbing Work	59 days	05-05-2024	03-07-2024	20,62,488	58 days	20,64,850
			TOTAL AMOUNT		**1,17,29,652**		**1,16,62,270**
	Contingencies 2%				2,34,593		2,33,245
	Escalation 2%				2,34,593		2,33,245
			NET AMOUNT		**1,21,98,838**		**1,21,28,761**
			GST 18 %		**21,95,791**		**21,83,177**
			GROSS AMOUNT		**1,43,94,629**		**1,43,11,938**

Fig -1.1: Live project data with annual cost

Initially as shown in Figure 3, a Gantt chart representing the project activities has been made in order to assist in developing of the Linear Programming Problem (LPP) model. In Gantt chart along the y axis, we can see the activities and on x axis, duration of each activity is represented.

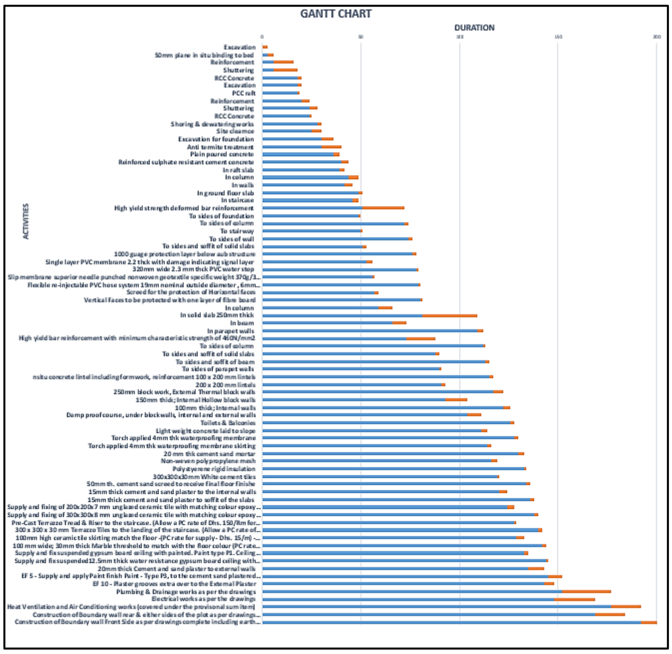

Fig -1.2: Gantt chart of project activities

The project network diagram has then been created, to determine the Critical Path Length and Project Duration as well as the Earliest Start Time, Earliest Finish Time, Latest Start Time, and Latest Finish Time as represented in fig. no. 04.

Activity	Description	Time	EST	EFT	LST	LFT	Slack	Criticality
1	Excavation	3	0	3	0	3	0	**
2	50mm plane in situ binding to bed	3	3	6	3	6	0	**
3	Reinforcement	10	6	16	10	20	4	
4	Shuttering	12	6	18	6	18	0	**
5	RCC Concrete	2	18	20	18	20	0	**
6	Excavation	2	18	20	18	20	0	**
7	PCC raft	1	18	19	19	20	1	
8	Reinforcement	4	20	24	20	24	0	**
9	Shuttering	4	24	28	24	28	0	**
10	RCC Concrete	1	24	25	24	25	0	**
11	Shoring & dewatering works	2	28	30	28	30	0	**
12	Site clearnce	5	25	30	25	30	0	**
13	Excavation for foundation	6	30	36	30	36	0	**
15	Anti termite treatment	10	30	40	30	40	0	**
17	Plain poured concrete	3	36	39	36	39	0	**
18	Reinforced sulphate resistant cement concrete	4	40	44	40	44	0	**
19	In raft slab	3	39	42	39	42	0	**
20	In column	5	44	49	44	49	0	**
21	In walls	4	42	46	42	46	0	**
22	In ground floor slab	2	49	51	49	51	0	**
23	In staircase	3	46	49	46	49	0	**
24	High yield strength deformed bar reinforcement	21	51	72	51	72	0	**
25	To sides of foundation	1	49	50	49	50	0	**

Fig -1.3: Calculation of EST, EFT, LST & LFT

7. PROJECT CRASHING USING LINEAR PROGRAMMING IN LINGO

As part of this methodological framework, we begin by meticulously developing a mathematical model that has been designed to handle every aspect of our project crashing condition. The main objective of this model, which is methodically constructed using Linear Programming techniques, is to minimize the overall cost of "crashing" or accelerating project activities. In order to provide an initial understanding, the project length is first approximated using network diagrams, like the Critical Path Method (CPM), or by using advanced project management software that accurately plots the duration of each action. For our particular scenario, this initial approximation provides a project duration that indicates the amount of time before any crashing operations.

The focus after that turns to defining critical decision variables that are essential to the optimization process. Here, we present 'X' as the variable that denotes the precise time at which a project event occurs. Particularly, this chronological measurement is made from the project's initiation or starting point, offering a comprehensive immediate framework for an in-depth analysis.

Therefore,

Y1 = time at which 1st event occurs

Y2 = time at which 2nd event occurs

Y 3 = time at which 3rd event occurs

Y4 = time at which 4th event occurs

Y5 = time at which 5th event occurs

Y6 = time at which 6th event occurs

Y7 = time at which 7th event occurs

Y8 = time at which 8th event occurs

Yn = No. of days activity n can be crashed.

In a similar manner, X1, X2, X3, X4, X5, X6, etc. represent for the number of days that can be crashed for Activities 2, 3, 4. 5, 6, 7, 8 etc., respectively

ACTIVITY NO.	ACTIVITY NAME	NORMAL TIME	CRASH TIME	NORMAL COST	CRASH COST	MAX CRASH TIME	CRASH COST PER DAY
1	Excavation	4	2.5	1,50,000	1,55,250	1.5	3,500
2	50mm plane in situ binding to bed	3	2	47,800	49,560	1	1,760
3	Reinforcement	10	8	4,46,800	4,50,045	2	1,623
4	Shuttering	12	11	9,000	11,250	1	2,250
5	RCC Concrete	2	1	2,55,216	2,60,000	1	4,784
6	Excavation	2	1	90,526	99,350	1	8,824
7	PCC raft	2	1	1,01,256	1,06,750	1	5,494
8	Reinforcement	4	3	1,52,962	1,56,450	1	3,488
9	Shuttering	4	3	5,962	8,050	1	2,088
10	RCC Concrete	2	1	1,90,564	2,05,250	1	14,686
11	Shoring & dewatering works	2	1	35,560	40,320	1	4,760
12	Site clearnce	5	3	20,800	22,580	2	890
13	Excavation for foundation	16	13	1,56,752	1,65,500	3	2,916
14	Anti termite treatment	10	8	23,426	26,540	2	1,557
15	Plain poured concrete	3	2	6,23,450	6,46,210	1	22,760
16	Reinforced sulphate resistant cement concrete	4	3	12,56,740	12,58,750	1	2,010
17	In raft slab	3	2	50,025	52,520	1	2,495
18	In column	5	3	25,450	26,780	2	665
19	In walls	4	3	21,070	25,100	1	4,030
20	In ground floor slab	2	1	35,463	38,740	1	3,277
21	In staircase	3	2	10,550	12,230	1	1,680
22	High yield strength deformed bar reinforcement	21	20	51,073	53,620	1	2,547
23	To sides of foundation	2	1	10,564	12,432	1	1,868
24	To sides of column	2	1	25,789	30,548	1	4,759
25	To stairway	2	1	19,870	23,634	1	3,764
26	To sides of wall	2	1	11,565	13,325	1	1,760
27	To sides and soffit of solid slabs	2	1	9,784	10,980	1	1,196
28	1000 guage protection layer below aub structure	2	1.5	8,900	10,235	0.5	2,670
29	Single layer PVC membrane 2.2 thck with damage indicating signal layer	3	2	12,000	14,340	1	2,340

Fig -2: Maximum crash time and time cost slope of each activity

45	200 x 200 mm lintels	2	1	7,895	8,261	1	366
46	250mm block work, External Thermal block walls	5	4	98,414	98,840	1	426
47	150mm thick; Internal Hollow block walls	11	9	1,11,450	1,15,230	2	1,890
48	100mm thick; Internal walls	4	3	75,457	78,560	1	3,103
49	Damp proof course, under blockwalls, internal and external walls	7	6	10,548	12,264	1	1,716
50	Toilets & Balconies	2	1	15,475	17,450	1	1,975
51	Light weight concrete laid to slope	3	2	14,754	16,360	1	1,606
52	Torch applied 4mm thk waterproofing n	2	1	7,894	10,955	1	3,061
53	Torch applied 4mm thk waterproofing n	2	1	9,784	13,410	1	3,626
54	20 mm thk cement sand mortar	3	2	5,784	8,358	1	2,574
55	Non-weven polypropylene mesh	3	2	2,475	3,000	1	525
56	Polystyerene rigid insulation	2	1	4,015	5,300	1	1,285
57	300x300x30mm White cement tiles	2	1	8,974	9,500	1	526
58	50mm th. cement sand screed to receive	2	1	15,784	16,050	1	266
59	15mm thick cement and sand plaster to	4	3	21,578	23,650	1	2,072
60	15mm thick cement and sand plaster to	2	1	19,574	21,740	1	2,166
61	Supply and fixing of 200x200x7 mm unglazed ceramic tile with matching colour epoxy grout. (Allow a PC rate of - Dhs. 40/m2 for supply of Ceramic) - CT-1	4	3.5	10,874	12,900	0.5	4,052
62	Supply and fixing of 300x300x8 mm unglazed ceramic tile with matching colour epoxy grout. (Allow a PC rate of - Dhs. 40/m2 for supply of Ceramic) - CT-1	2	1	24,784	27850	1	3,066
63	Pre-Cast Terrazzo Tread & Riser to the staircase. (Allow a PC rate of Dhs. 150/Rm for supply of Terrazzo) TR 3	2	1	3,278	4000	1	722
64	300 x 300 x 30 mm Terrazzo Tiles to the landing of the staircase. (Allow a PC rate of Dhs. 50/m2 for supply of Terrazzo) TR-1	2	1	8,947	9200	1	253

Fig -2.1

In the above figures no. 5 and 5.1, excel is used to determine the normal time, crash time, normal cost, and crash cost.

As we can see in fig no. 03, the start time of every activity depends on the start time and duration of its immediate predecessors. Furthermore, as shown in Table 5 & 5.1, the crash cost per day, also known as the cost slope, has been calculated. We developed the following objective function using this cost slope and the decision variable X, which indicates the number of days an activity should be crashed:

```
Min(Z)= 4322x1 + 24597x2 + 7644x3+ 1557x4 + 23338x5+ 4575x6 + 5255x7 + 513x8 + 14438x9 + 2005x10 + 3622x11+ 4504x12+ 12134x13+ 9426x14+ 1925x15+ 1789x16+ 2986x17+ 2006x18+ 2004x19+ 2015x20+ 4030x21+ 23620x22
```

Z here is Objective function value which represents minimum crash cost & X represents the number of days each activity can be crashed i.e. for 22 activities.

The constraints are taken into consideration such as non-negative constraints, crash time constraints, start time constraints & project completion constraints. Few are mentioned below:

Non negative constraint:

```
x1 >= 0
x2 >= 0
x3 >= 0
x4 >= 0
x5 >= 0
x6 >= 0
x7 >= 0
x8 >= 0
x9 >= 0
x10 >= 0
```

Crash time constraints:

```
x1 >= 4
x2 >= 1
x3 <= 2
x4 >= 2
x5 >= 5
x6 >= 2
x7 >= 2
x8 >= 8
x9 >= 1
x10 >= 5
```

Start time constraints:

```
y1 = 0
y2 +x2 >= 12
y3- x3+ y2 >= 20
y4- x4+ y3>= 10
y5- x5+ y4 >= 24
y6- x6+ y5>= 11
y7- x7+ y6>=45
y8- x8+ y7>= 21
y9- x9+ y8>= 10
y10- x10+ y9>= 27
```

Project completion constraint:

```
Yfinish <= 501
```

And similarly for 22 activities.

7.2. PROCEDURE FOLLOWED IN LINGO

We construct a collection of variables to represent important project components in the first stage of using Lingo to optimize the project time. More specifically, we declare a variable called 'x' that represents the maximum number of days that an activity can crash. We also define a variable 'y' to indicate the time at which each event takes place, and 'y_finish integer' is used to indicate the time at which the project is finished.

We construct a collection of variables to represent important project components in the first stage of using Lingo to OPTIMIZE the project time. More specifically, we declare a variable called 'x' that represents the maximum number of days that an activity can crash. We also define a variable 'y' to indicate the time at which each event takes place, and 'y_finish integer' is used to indicate the time at which the project is finished.

Through systematic consideration of these factors, building the objective function, and implementation of suitable constraints, Lingo's optimization process is set up to produce a solution that minimizes project expenses and duration. Then, we go along and execute the model in our Lingo model after thoroughly outlining the variables, creating the objective function, and establishing the constraints. The process of optimization finalizes in the generation of results that provide significant understanding of the optimal approach to reduce project duration as well as associated costs.

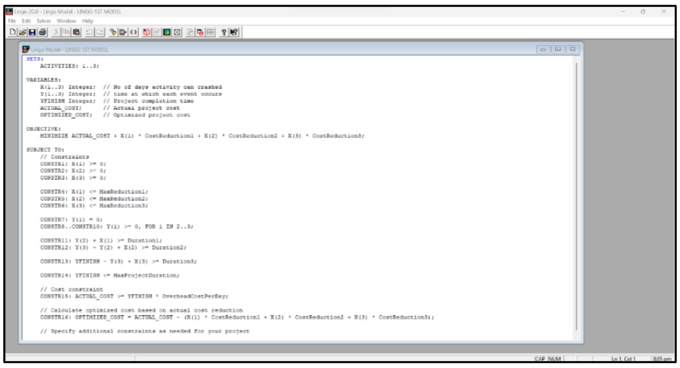

Fig -3: Model 1 in LINGO

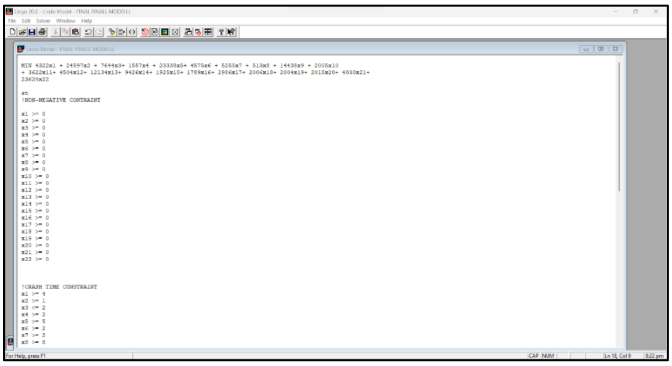

Fig -3.1: Final working model

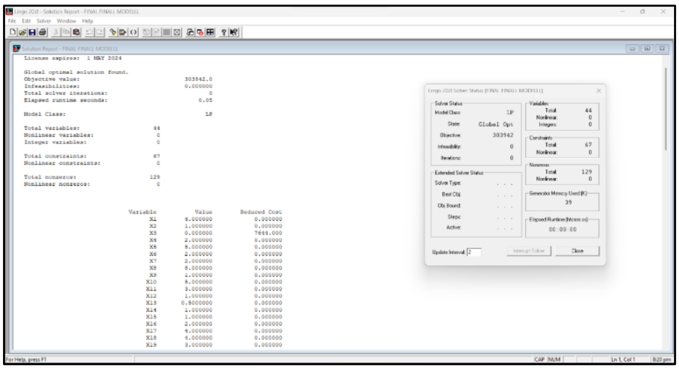

Fig -3.2: Final solution in LINGO

7.3. RESULTS FOR LPP MODEL IN LINGO

The objective value, 'x' and 'y' values, and other outputs from the Lingo optimization process are displayed in the table below. Additionally, the graphical representation of Plotting activities on the abscissa and their corresponding durations on the ordinates is done. The graph illustrates the duration of each activity after and before the optimization.

OBJECTIVE	FINAL VALUE		
Z	3,03,942		
X1	4	Y1	0
X2	1	Y2	11
X3	0	Y3	9
X4	2	Y4	3
X5	5	Y5	26
X6	2	Y6	0
X7	2	Y7	47
X8	8	Y8	0
X9	1	Y9	11
X10	5	Y10	21
X11	3	Y11	0
X12	1	Y12	9
X13	0.5	Y13	0.5
X14	1	Y14	14.5
X15	1	Y15	0
X16	2	Y16	6
X17	4	Y17	18
X18	4	Y18	11
X19	3	Y19	37
X20	2	Y20	47
X21	1	Y21	0
X22	1	Y22	60
Y FINISH			0

Table -1: X and Y solution in LINGO

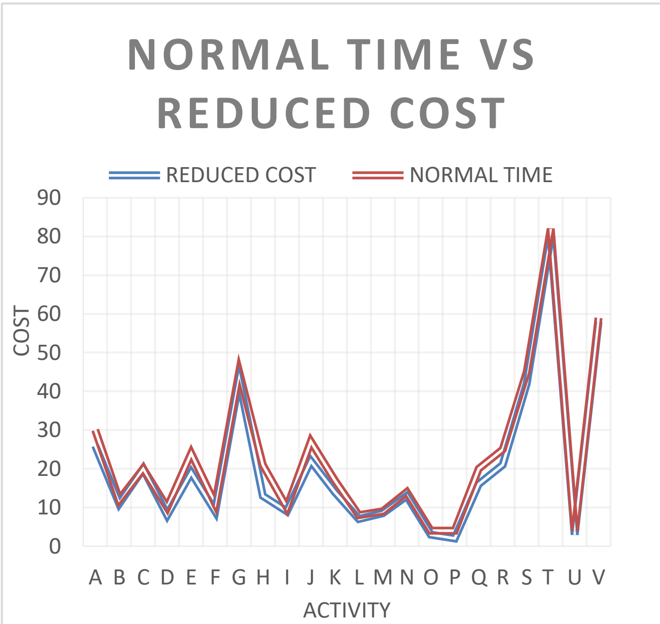

Fig -4: Time Distribution for each activity of Project

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Our analysis has shown that, if the project is carried out in 530 days without using the crashing method, the total cost will be Rs 1,38,46,314. On the other hand, the project expenses increase to Rs. 1,41,50,256 if the crashing approach is used to meet the same 447-day completion deadline. The table below provides a summary of these findings' details.

Project Duration	Direct Cost	The cost after Crashing	Total Cost
501 days	1,38,46,314	-	1,38,46,314
447 days	1,38,46,314	3,03,942	1,41,50,256

Table -2: Total Cost Before and After Crashing.

8. PROCEDURE FOLLOWED IN PRIMAVERA P6

In order to achieve particular objectives, tasks must be arranged with specific start and finish points through project management. Project portfolios, which are controlled by an Enterprise Project Structure (EPS), allow for the viewing of data simultaneously. Critical responsibilities such as project, sales, and human resource managers are assigned under the Work Breakdown Structure (WBS). Project, Resource, and Global calendars are used by Primavera P6 to schedule resources and tasks, which is essential for efficient project management. The Work Breakdown Structure (WBS), which is especially important for multistory residential complexes, organizes project work. Activities are shown in a schedule chart that shows task durations and is handled by relationships (FS, SS, FF, SF). For effective task completion, resources—including labor and machinery—are categorized according to unit costs and working hours. The Critical Path Methodology helps with scheduling, figuring out when a project should be finished, and identifying important paths.

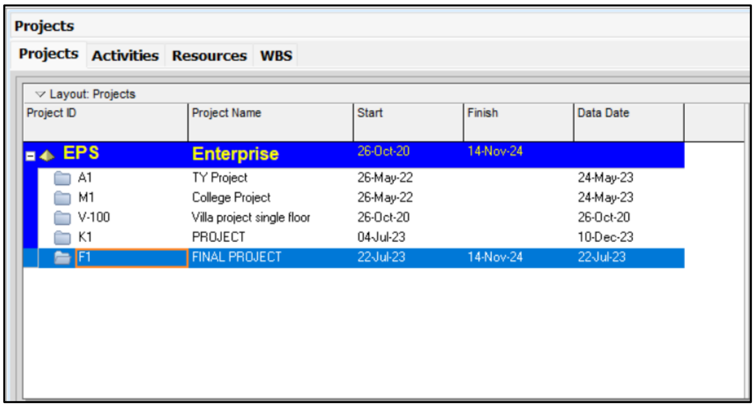

Fig -5: Project Portfolio

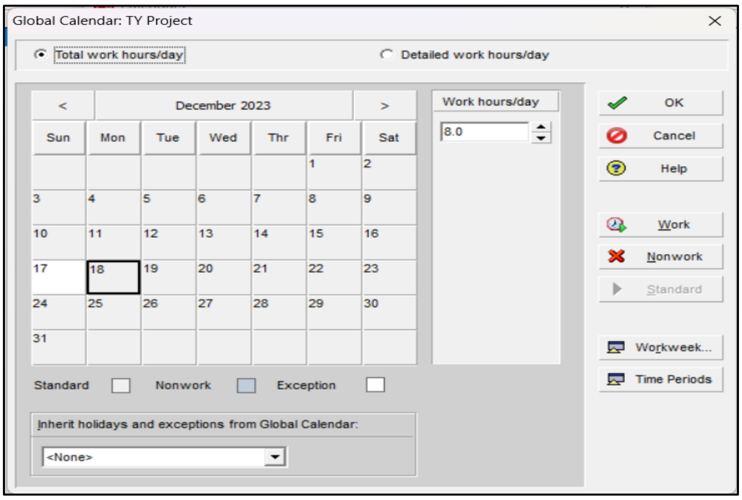

Fig -5.1: Calendar

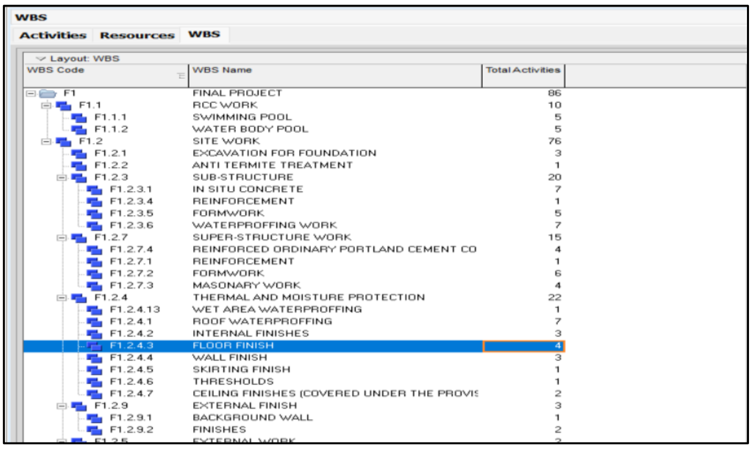

Fig -5.2: Work Breakdown Structure

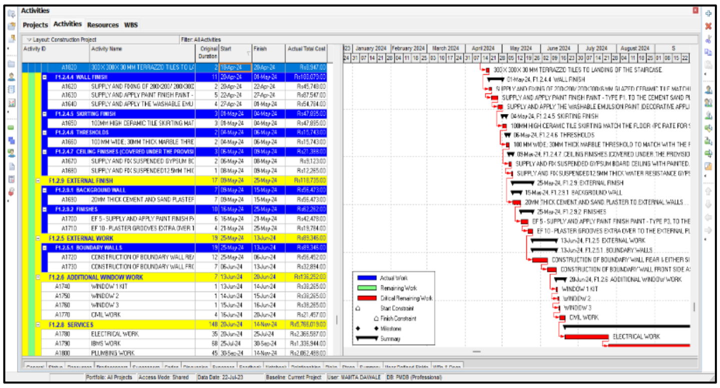

Fig -5.3: Activities and Scheduling Chart

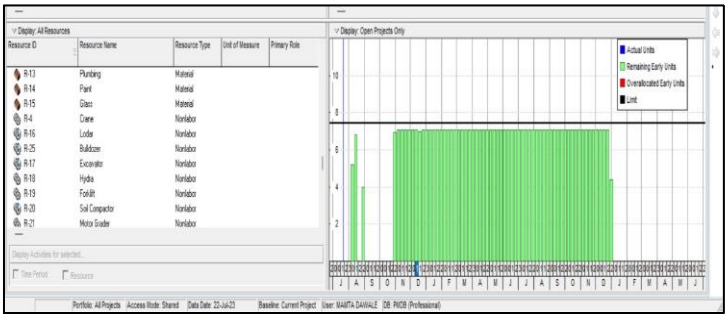

Fig -5.4: Resources Curves

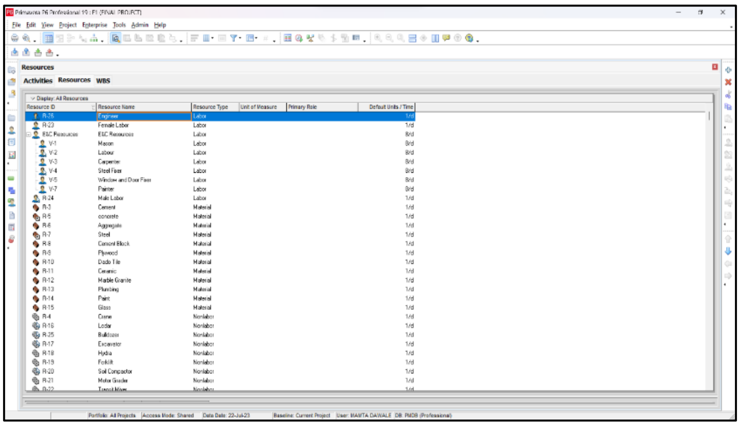

Fig -5.5: Resources

8.1 RESULTS FOR PRIMAVERA P6

We discovered that the project will optimize cost was lower than its budgeted cost but only if we rescheduled and reallocated the resources and a new critical path and an optimized duration following the schedule crash.

Sr. No.	Type	cost
1.	Budgeted total cost	Rs. 1,38,46,314
2.	Optimized cost	Rs1,72,45,720

Table -3: Total Cost Before and After Crashing.

Sr. No.	Type	cost
1.	Original Duration	501 Days
2.	After Crashing	486 Days

Table -4: Total duration Before and After Crashing.

9. RESULTS AND CONCLUSION

According to the research findings, Lingo's use of linear programming (LP) significantly reduced the project's duration by 54 days, resulting in a cost of Rs. 1,41,50,256 for project activity disruption. It may be feasible to reduce the project duration even further, but doing so requires additional funds. **Lingo has reduced project duration by 8.9%, a noteworthy figure considering that the cost was just Rs. 3,03,942.**

Alternatively, with a total scheduling cost of Rs. 1,72,45,720, the project duration is shortened by 15 days when using Primavera P6. **This results in a 2.3% reduced project duration, achieved with a 33,99,406 reduction in cost.** Even though the cost of crashing increases up, the effect has been mitigated because, over the best part of the project's duration, the indirect costs are reduced as a result.

10. TECHNICAL COMPARISON BETWEEN LINGO AND PRIMAVERA P6

A. Efficiency of Optimization:

a. In comparison to Primavera P6, Lingo shows a greater percentage reduction in project length (8.9%).

b. Primavera P6 reduces overall costs by a significant amount but at a lesser percentage (2.3%).

B. Benefit-Cost Analysis:

a. Lingo spends comparatively less (Rs. 3,03,942) for a project that is completed much faster.

b. While Primavera P6 delivers a relatively bigger overall cost reduction (Rs. 33,99,406), the reduction is not as significant.

C. Sensitivity to Costs of Crashing:

a. Lingo exhibits sensitivity to cost crashing, where there is a more noticeable decrease in project duration.

b. Primavera P6 shows a less noticeable decrease in project length, indicating a less responsive response to plummeting prices.

D. Trade-off Between Cost and Duration:

a. Lingo provides better control over the optimization process by demonstrating a more distinct trade-off between project length and crashing expenses.

b. Primavera P6 promotes flexibility in decision-making by striking a balance between cutting project time and lowering overall costs.

E. User-Friendliness:

a. Users may face a longer learning curve as lingo may require a deeper comprehension of linear programming ideas.

b. Primavera P6 is well-known for having a simple interface that allows planners and project managers to use it more widely.

F. Capabilities for Integration:

a. It's possible that Lingo's integration capabilities with other project management software and tools are limited.

b. Enhancing interoperability, Primavera P6 is frequently effortlessly connected with a variety of scheduling and project management applications.

G. Risk Reduction:

a. Lingo's ability to precisely regulate project time and crashing costs makes it possible to implement careful risk management.

b. Primavera P6 offers a more cautious approach to risk mitigation because of its emphasis on striking a balance between overall expenses and reduction**.**

In conclusion, the decision between Primavera P6 and Lingo is based on the planned trade-off between project duration and costs, user skills, and project-specific objectives. Primavera P6 is a potential solution for a wider user base due to its user-friendly interface and integration possibilities, even if Lingo may offer enhanced control over optimization conditions

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