

Optimal Scheduling for Repetitive Projects using Suitable planning Technique

A Thesis

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Building Management

by

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**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
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Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **S RAM AKSHAYA (39840017)** who carried out the Thesis entitled "**Optimal Scheduling for Repetitive Projects using suitable Planning Technique**" under our supervision from January 2021 to May 2021.

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DECLARATION

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ABSTRACT

Repetitive projects represent a large portion of the construction industry. Scheduling of repetitive projects always represent a major challenge to project managers.

This Research was about Optimizing Time planning of Repetitive Construction Project. Various techniques followed for Scheduling was analyzed in this Research and also Currently practiced scheduling technique in the market was compared with Line of Balance method and difference in their time planning was found.

A mid-Rise residential structure was taken as a live case study and with their currently planned Schedule a line of balance graph was made. With the line of balance graph, optimization of the planning was done. Overall, the project was about reducing the float time and increasing Work continuity of the project using LOB and Commonly practicing method like CPM.

Keywords: Repetitive Projects, Repetitive Scheduling, Line of Balance.

TABLE OF CONTENTS

CHAPTER No	TITLE	PAGE No
	ABSTRACT	v
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
1	INTRODUCTION	1
	1.1 INTRODUCTION	1
	1.2. AIM	1
	1.3. OBJECTIVES	1
	1.4. METHODOLOGY	2
	1.5. LIMITATION	2
2	LITERATURE STUDY	3
	2.1. A CASE STUDY: LINE OF BALANCE (LOB) METHOD FOR HIGH RISE RESIDENTIAL PROJECT	5
	2.1.1. OBJECTIVE	6
	2.1.2 SOFTWARE TOOL	6
	2.1.1. INFERENCES	7
	2.2. SCHEDULING OF REPETITIVE CONSTRUCTION PROJECTS USING GEOGRAPHIC INFORMATION SYSTEMS: AN INTEGRATION OF CRITICAL PATH METHOD AND LINE OF BALANCE	
	2.2.1. OBJECTIVE	
	2.2.2. RESULTS	11

3	LIVE CASE STUDY	13
	3.1. INTRODUCTION	13
	3.2. LINE OF BALANCE - SOFTWARE	29
	3.2.1. LINE OF BALANCE: SCHEDULE INTEGRATION	29
	3.2.2. PLANNED SCHEDULE	30
	3.2.3. EXCEL SHEET - LINE GRAPH - SUPER STRUCTURE CIVIL WORKS	33
	3.2.4. EXCEL SHEET - LINE GRAPH - SUPER STRUCTURE FINISHING WORKS	33
	3.3. POWERPROJECT BIM SCHEDULE	35
	3.3.1. SCHEDULE	35
	3.3.2. LINE GRAPH – REPETITIVE FLOOR CIVIL WORKS & FINISHING WORKS	37
	3.3.3. LINE GRAPH – REPETITIVE FLOOR CIVIL WORKS & INTERNAL FINISHING WORKS – PAINTING WORK	38
	3.3.4. LINE GRAPH – REPETITIVE FLOOR CIVIL WORKS & INTERNAL FINISHING WORKS – FLOORING WORKS	39
	3.3.5. LINE GRAPH – REPETITIVE FLOOR CIVIL WORKS & INTERNAL FINISHING WORKS – JOINERIES	40
	3.3.6. LINE GRAPH – REPETITIVE FLOOR CIVIL WORKS & INTERNAL FINISHING WORKS – OPTIMIZED OUTPUT	41
	3.4. OPTIMIZED SCHEDULE	41

4	CONCLUSION	
	4.1. RESULTS	48
	4.2. CONCLUSION	48
	4.3. FUTURE RESEARCH	49
	REFERENCES	50

LIST OF TABLES

TABLE No.	TITLE	PAGE No.
2.1	Project Schedule	5
2.2	Gang Size results	7
2.3	Output of developed tool	11
3.1	Project Details	13
3.2	Block Details	22
3.3	Sub Structure WBS	23
3.4	Super Structure WBS	25
3.5	Finishing Works	27
3.6	Repetitive Activities	28
3.7	Actual Planned Schedule	32

LIST OF FIGURES

FIGURE No.	TITLE	PAGE No.
1.1	Project Methodology	2
1.2	Project Limitation	2
2.1.	Theoretical gang size Histogram	3
2.2	Actual gang size Histogram	3
2.3	Gang Size Calculations	4
2.4	Flow lines with Gantt chart view using VICO Control Software	6
2.5	Duration in Days	10
2.6	Schedule of repetitive construction project with time constant	50
2.7	4D Modelling of the developed integrated construction Schedule	12
3.1	Project Render	13
3.2	Site cum Typical Plan	14
3.3	Typical Plan– Block A & E – Flat 1	15
3.4	Typical plan – Block A & E – Flat 2	15
3.5	Typical plan – Block A & E – Flat 3	16
3.6	Typical plan– Block A & E – Flat 4	16
3.7	Typical plan– Block B & D – Flat 1	17
3.8	Typical plan– Block B & D – Flat 2	17
3.9	Typical plan– Block B & D – Flat 3	18
3.10	Typical plan– Block B & D – Flat 4	18
3.11	Typical plan– Block C – Flat 1	19
3.12	Typical plan– Block C – Flat 2	19

3.13	Typical plan – Block C – Flat 3	20
3.14	Typical plan – Block C – Flat 4	20
3.15	Multipurpose hall	21
3.16.	Block selected for Research	22
3.17.	Software Icon	29
3.18.	Software template figure	29
3.19.	Sample Line of balance using Software	29
3.20.	Line Graph – Super Structure Civil Works	33
3.21.	Line Graph – Super Structure Finishing Works	33
3.22.	Overall Line Graph using Excel	34
3.23.	BIM Schedule	36
3.24.	Powerproject BIM - Line graph –Civil works	37
3.25.	Powerproject BIM - Line graph –Civil works & finishing works	38
3.26.	Powerproject BIM - Line graph –Civil works & finishing works – Output	39
3.27.	Powerproject BIM - Line graph –Civil works & finishing works – Painting Works	40
3.28.	Powerproject BIM - Line graph –Civil works & finishing works – Flooring works	42
3.29.	Powerproject BIM - Line graph –Civil works & finishing works – Flooring works	43
3.30.	Powerproject BIM - Line graph –Civil works & finishing works – Flooring works	43
3.31.	Actual schedule graph	45
3.32.	Optimized schedule graph	45
3.33.	Optimized BIM schedule	47

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Many civil and building construction tasks are conducted on a regular basis. These projects are referred to as repetitive or linear projects. A major amount of the construction sector is made up of repetitive projects.

A set of tasks is repeated in each unit throughout the duration of the job in repetitive construction projects. An activity must be repeated after it has been started and/or completed in one unit. Repetitive construction projects can be categorized into two types based on the direction of consecutive work along the units.

- Horizontal repetitive projects
- Vertical repetitive projects

Various scheduling techniques:

- Bar chart / Gantt chart
- Networking techniques
 - Critical Path Method - CPM
 - Project Evaluation & Review Technique
- Line of Balance (LOB)

1.2 AIM

The aim of this research is to do an optimal Schedule for repetitive Construction project using suitable planning technique.

1.3 OBJECTIVES

- To understand various methods of repetitive project scheduling.
- To study the current practices followed for Repetitive Construction project and their Scheduling methods.
- To optimize the Scheduling by reducing the Float time and Increasing the work continuity using suitable planning Method.

1.4 METHODOLOGY

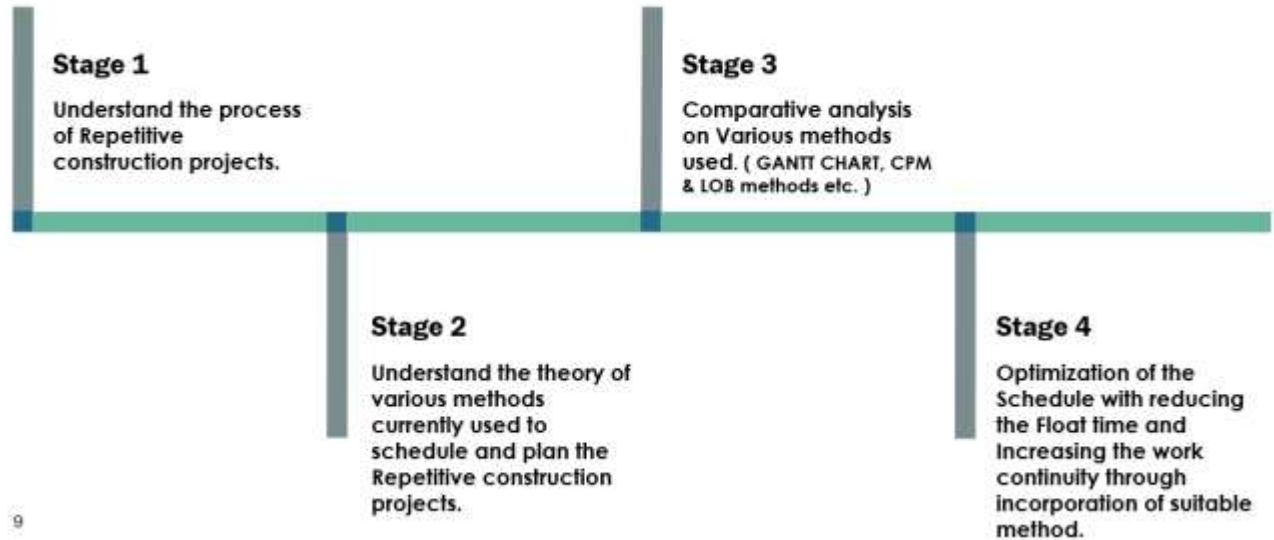


Fig 1.1 Project methodology

1.5 LIMITATIONS



Fig 1.2 Project Limitation

The basic TRIPLE CONSTRAINTS of Project Management are

- Time
- Cost
- Scope

I limit my study to the Time planning process of Repetitive Construction Project to bring in work continuity keeping Cost and Scope as stable.

CHAPTER 2

LITERATURE STUDY

2.1. A case study: line of balance (lob) method for high rise residential project

The line of balance technique of project scheduling is used for work that is repetitive in nature, such as housing projects, urban residential development, road construction, high-rise construction buildings, pipelines, and precast concrete production. When employing a series of flow line graphs to monitor a project, when a Gantt chart graph does not provide much detail, the LOB technique becomes easier to visualise and operate. It is critical for the project manager to manage the project within a certain set of constraints, ensuring that resources are used to their full potential. The overall goal of this research is to determine the entire duration necessary for a project's completion and compare it to the actual plan using the line of balance approach, as well as to determine the project's float and show it using a flow line chart for repetitive tasks.

2.1.1. Objective

The goal of this research is to apply the Line of Balance (LOB) method to a project with repeated tasks, as well as to use LOB to continuous project monitoring at each milestone. The effective force ratio is calculated using LOB resource allocation and resource levelling, which aids in resource optimization.

VICO software is used to determine the total duration necessary for a project's completion and compare it to the actual plan using the line of balance method and VICO software, as well as to determine the float in the project and show it using a flow line chart for repetitive operations.

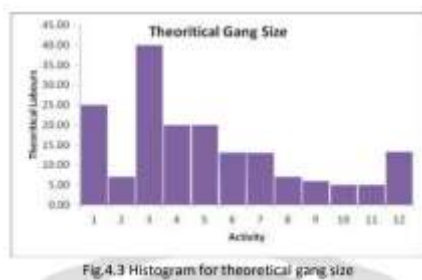


Fig.4.3 Histogram for theoretical gang size

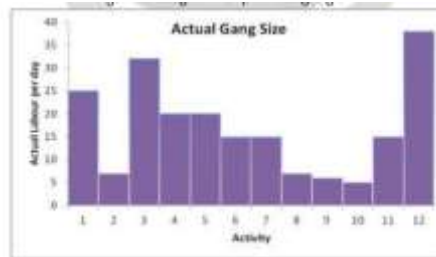


Fig.4.2 Histogram for actual gang size

Fig 2.1 Theoretical gang size Histogram

Fig 2.2 Actual gang size Histogram

3.3 Formula for calculate crew size:

Calculation for activity

1. Theoretical Gang Size at Chosen output rate (G)
 $G = (R \times \text{Man hour per unit}) / (\text{No. of working hour per man per week})$
 $G = (2 \times 600) / (6 \times 8)$
 $G = 25$
2. Actual Gang Size (Ga)
 $G_a = \text{Actual gang size}$
 $G_a = 25$
3. Actual Rate of output (Ra)
 $R_a = R \times (G_a / G)$
 $R_a = 2 \times (25 / 25)$
 $R_a = 2$
4. Actual Duration for one unit (D)
 $D = (\text{Man hour per unit}) / (\text{No. of Man per Gang} \times \text{No. of working hours per man per day})$
 $D = 600 / (38 \times 8)$
 $D = 1.97$
Number of working hours per day = 8 Hours
5. Time from start on first unit to start on last unit (T)
 $T = (n - 1) \times \text{No. of working days per week} / R_a$
 $T = (21 - 1) \times 6 / 2.2$
 $T = 54.54$
 $n = \text{total number of repetition}$
 $n = 21$

Fig 2.3 Gang size Calculations

A graph is plotted for the resource needs against the period of necessity, and this is known as a Resource Usage Profile or, in statistical terms, a Histogram. It's a bar graph of raw data that shows how the data is

distributed.

Table 1: Calculation for LOB

Activity	Duration (days)	Start Date	Finish Date	Avg. Labours per day	Working Hours	Total Working Hours	Theoretical Gang Size (G)	Actual Gang Size (Ga)	Actual Output Rate (Ra)	Actual duration for one unit (D)	Time from Start on first unit to start on last unit (T)	Buffer (B)
D - 3rd - 4th Column & N. S. Walls Reinforcement	3	Fri 12/08/16	Wed 17/08/16	25	8	600	25.00	25	2.0	3.0	60.0	0
D - 3rd - 4th Columns & N. S. Walls Elec & Plumbing Conducting	3	Fri 12/08/16	Wed 17/08/16	7	8	168	7.00	7	2.0	3.0	60.0	0
D - 3rd - 4th Column & N. S. Walls Shuttering	3	Sat 13/08/16	Thu 18/08/16	40	8	960	40.00	32	1.6	3.8	75.0	0
D - 4th Slab Beam Bottom	3	Sat 13/08/16	Thu 18/08/16	20	8	480	20.00	20	2.0	3.0	60.0	0
D - 4th Slab Shuttering	3	Sat 13/08/16	Thu 18/08/16	20	8	480	20.00	20	2.0	3.0	60.0	0
D - 4th Slab Beam Reinforcement	3	Tue 16/08/16	Fri 19/08/16	13	8	312	13.00	15	2.3	2.6	52.0	0
D - 4th Slab Reinforcement	3	Tue 16/08/16	Fri 19/08/16	13	8	312	13.00	15	2.3	2.6	52.0	0
D - 4th Slabs Elec & Plumbing Conducting	3	Tue 16/08/16	Fri 19/08/16	7	8	168	7.00	7	2.0	3.0	60.0	0
D - 4th Slab Beam outer Sides	3	Tue 16/08/16	Fri 19/08/16	6	8	144	6.00	6	2.0	3.0	60.0	0
D - 4th Slab Outer Sides	3	Tue 16/08/16	Fri 19/08/16	5	8	120	5.00	5	2.0	3.0	60.0	0

Table 2.1 Project Schedule

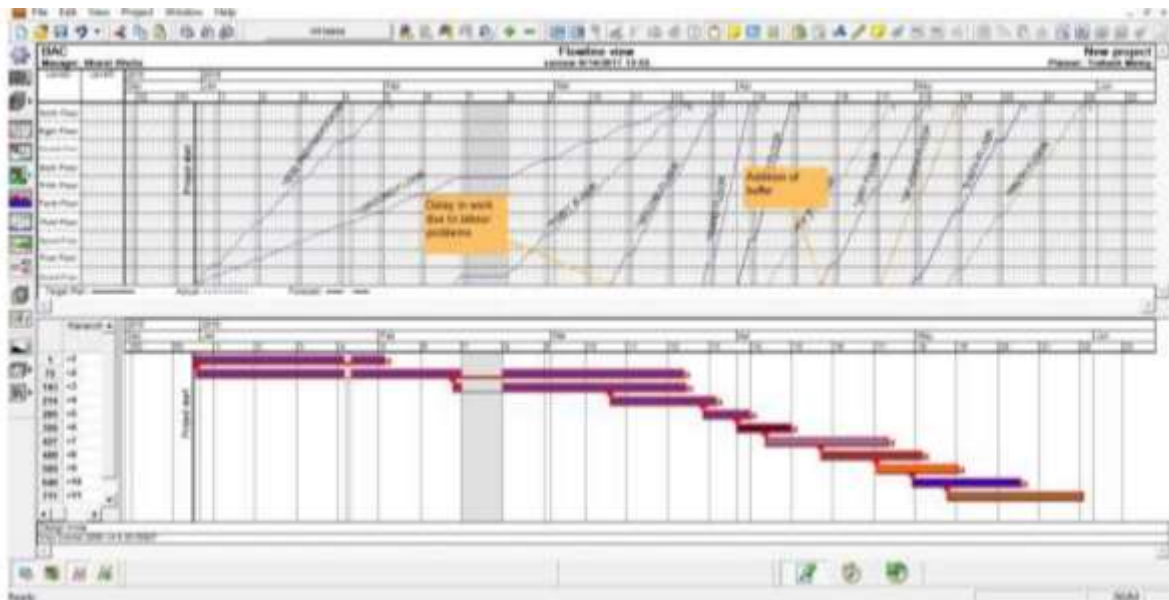


Fig 2.4 Flow lines with Gantt chart view using VICO Control Software

2.1.2. Software Tool

The Resource Usage Profile, or in statistical terms, a Histogram, is a graph that plots the resource requirement versus the time period of requirement. It's a raw data bar graph that depicts the distribution of the data.

On the data collection reported in table 1, the line balance method (LOB) is used. The rate of production, or efficiency, is estimated, which aids in the drafting of the project's progress flow line. MIVAN formwork construction for high-rise buildings consists of a series of activities that are repeated. Take, for example, the rate at which an activity progress.

Table 6.1: Results for Gang size

Activity	Planned Labours per day	Actual Gang Size (Ga)	Theoretical Gang Size (G)
D - 3rd - 4th Column & N. S. Walls Reinforcement	25	25	25
D - 3rd - 4th Columns & N. S. Walls Elec & Plumbing Conduiting	7	7	7
D - 3rd - 4th Column & N. S. Walls Shuttering	40	32	40
D - 4th Slab Beam Bottom	20	20	20
D - 4th Slab Shuttering	20	20	20
D - 4th Slab Beam Reinforcement	13	15	13
D - 4th Slab Reinforcement	13	15	13
D - 4th Slabs Elec & Plumbing Conduiting	7	7	7
D - 4th Slab Beam outter Sides	6	6	6
D - 4th Slab Outer Sides	5	5	5
D - Columns + NS + 4th Slab beams (M-30) and 4th Slab RMRCC (M-30) Grade	15	15	5
D - 4th Slab Aluform Centering & Shuttering	40	38	13.33

Table 2.2 Gang size results

2.1.2. Inference

- The line of balance method works well for determining the rate of production for each activity based on crew size.
- Increasing the number of workers boosts the project's production rate, but it also raises the cost.
- The implementation of VICO Control 2009 software aids in the planning and visualization of activities in each site in an efficient manner.
- The activity rate, which is determined using the line of balance formula, can be compared.
- Required resources, i.e., labours, can be determined using a formula that yields theoretical and practical results.

2.2. Scheduling of repetitive construction projects using geographic information systems: an integration of critical path method and line of balance.

For scheduling non-repetitive construction projects, the critical path method (CPM) is frequently utilized; for scheduling repetitive construction projects, the line of balance (LOB) is utilized. In a building project, there may be both repetitive and nonrepetitive aspects. CPM and LOB approaches were combined within the geographic information systems environment in this study to schedule repetitive and non-repetitive components of a construction project together. Activities of a repeated portion are scheduled using CPM, and distinct repetitive parts are scheduled using LOB, according to the scheduling tool.

2.2.1. OBJECTIVE:

The main objective of the present study was to develop the tool for scheduling of repetitive and non-repetitive part of a construction projects in the GIS environment which was accomplish through:

Development of the tool for critical path method in the GIS environment for scheduling of non-repetitive part and a single unit of a repetitive construction project.

Development of the tool for scheduling of repetitive units using the concept of line of balance for a repetitive construction project. • Linking of the developed repetitive schedule with the corresponding 3D components to develop 4D model of the execution sequence in GIS environment.

Tool for non-repetitive scheduling:

The tool to schedule non-repetitive part and scheduling of a repetitive unit of a repetitive construction project has been developed using an open-source programming language known as python in ArcGIS.

Tool for repetitive scheduling:

The tool for scheduling of repetitive units of a repetitive construction project has also been developed using python in ArcGIS using the concept of LOB.

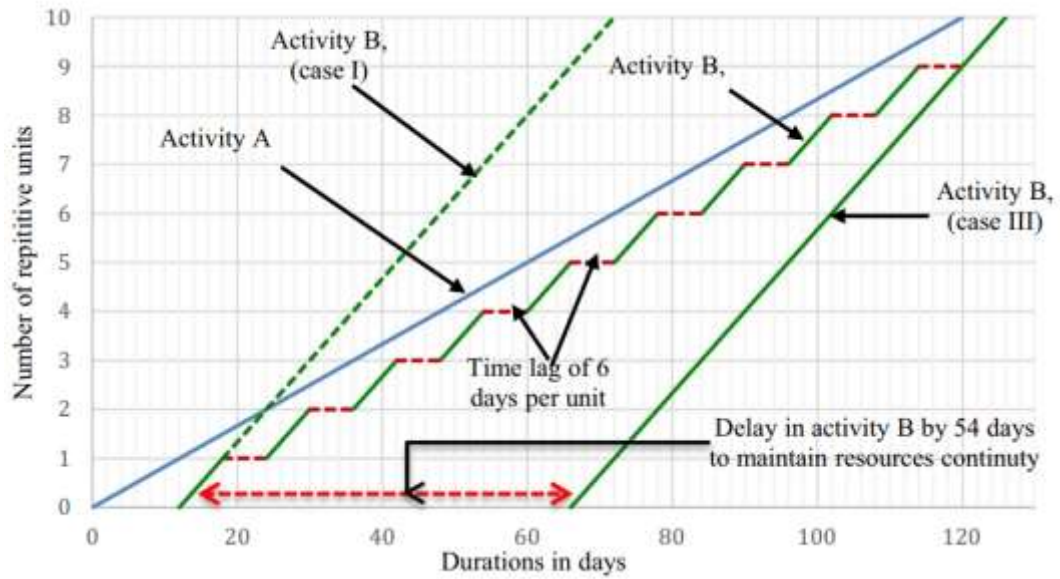


Fig 2.5 Duration in days

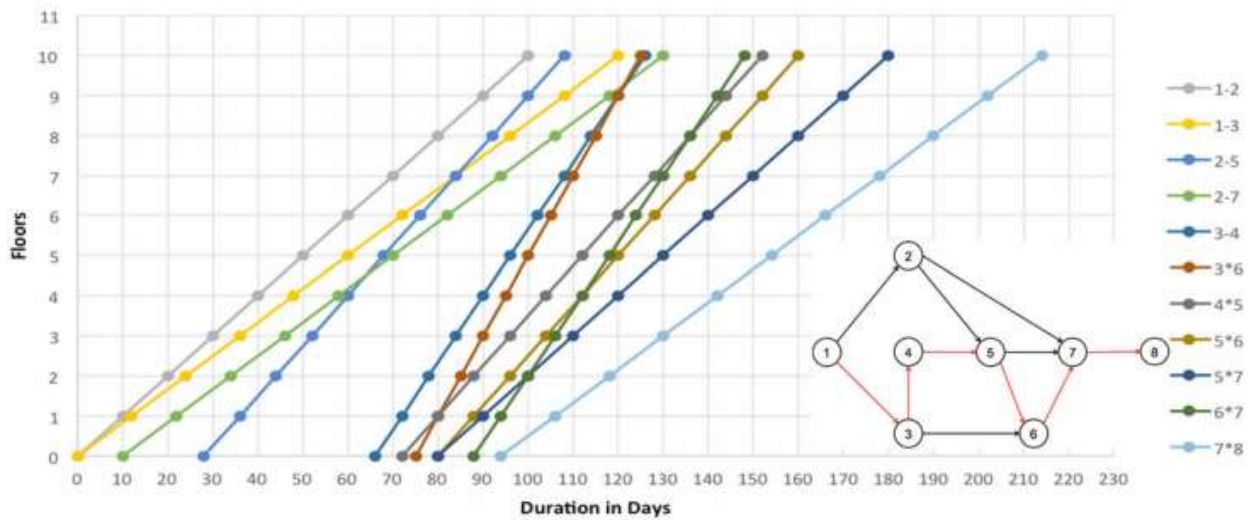


Fig 2.6 Schedule of repetitive construction project with time constant

Activity	Activity Discription	Activity ID	Activity Duration	From NODE	To NODE	R1	R2	R3	R4
1 --- 2	--select activity--	110021	10	1	2	2	4	3	2
1 --- 3	--select activity--	110022	12	1	3	1	0	2	1
2 --- 5	--select activity--	110023	8	2	5	5	2	1	3
2 --- 7	--select activity--	110024	12	2	7	4	2	0	1
3 --- 4	--select activity--	110025	6	3	4	2	2	1	3
3 --- 6	--select activity--	110026	5	3	6	2	3	2	2
4 --- 5	--select activity--	110027	8	4	5	4	2	1	0
5 --- 6	--select activity--	110028	8	5	6	2	1	1	2
5 --- 7	--select activity--	110029	10	5	7	1	0	1	0
6 --- 7	--select activity--	110030	6	6	7	2	3	2	1
7 --- 8	--select activity--	110031	12	7	8	1	1	1	0

(a)

Activity	From NODE	To NODE	Duration	EST	EFT	LST	LFT	Total Float	Free Float	Independent Float	Interfering Float	R1	R2	R3	R4
1 --- 2	1	2	10	0	10	8	18	8	0	0	8	2	4	3	2
1 --- 3	1	3	12	0	12	0	12	0	0	0	0	1	0	2	1
2 --- 5	2	5	8	10	18	18	26	8	8	0	0	5	2	1	3
2 --- 7	2	7	12	10	22	28	40	18	18	10	0	4	2	0	1
3 --- 4	3	4	6	12	18	12	18	0	0	0	0	2	2	1	3
3 --- 6	3	6	5	12	17	29	34	17	17	17	0	2	3	2	2
4 --- 5	4	5	8	18	26	18	26	0	0	0	0	4	2	1	0
5 --- 6	5	6	8	26	34	26	34	0	0	0	0	2	1	1	2
5 --- 7	5	7	10	26	36	30	40	4	4	4	0	1	0	1	0
6 --- 7	6	7	6	34	40	34	40	0	0	0	0	2	3	2	1
7 --- 8	7	8	12	40	52	40	52	0	0	0	0	1	1	1	0

(b)

Output of the developed tool **a** information entered; **b** schedule of a single repetitive unit

Table 2.3 Output of the developed tool

2.2.2. RESULTS

A sample project scheduled using the CPM methodology takes 520 days, while it takes 214 days if the same project is scheduled using the developed tool. Furthermore, construction planning is not done in isolation, that is, without taking into account the surrounding environment of the construction project in question. The scheduling tool created in a GIS context takes into account the impact of the environment on the established integrated schedule. To generate a 4D model of a construction project's execution sequence, a link has been made between the activities of the generated schedule and the relevant 3D components in a GIS environment. This facilitates in checking logical errors, resource continuity, and incompleteness of the developed integrated schedule.

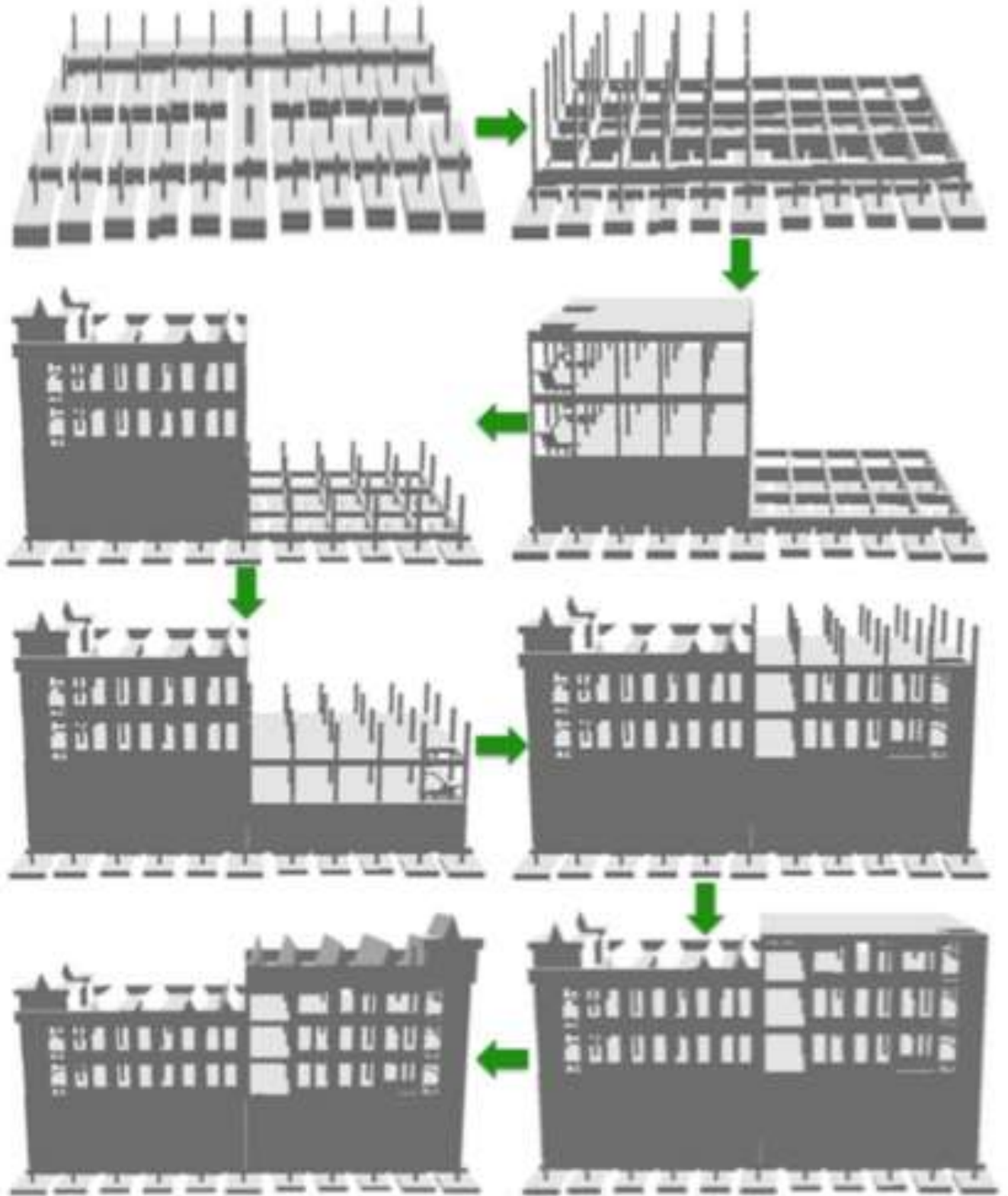


Fig 2.7 4D Modelling of the developed integrated construction Schedule

CHAPTER 3

CASE STUDY

3.1 INTRODUCTION

The residential apartment project “Celesta” is located at Pallikaranai. The project is on 23.1 grounds with stilt plus five structure is strategically positioned with all essentials that can expect in an urban lifestyle.

PROJECT NAME	CELESTA
CLIENT NAME	KRISHNA CONSTRUCTION
LOCATION OF THE PROJECT	JAYACHANDRAN NAGAR, PALLIKARANAI, CHENNAI
TYPE OF PROJECT	RESIDENTIAL APARTMENT
PROJECT AREA	55,440 SQ. FT
PROJECT DURATION	18 MONTHS
COST OF THE PROJECT	24.35 CR.

Table 3.1 Project details



Fig 3.1 Project Render

3.1.1. FLOOR PLANS



Fig 3.1 Site cum stilt plan



Fig 3.2 Site cum typical plan

3.1.1.1. TYPICAL FLOOR PLAN (BLOCK A & E)

- FLAT 1
- 3BHK – 1550 SQFT



Fig 3.3 Typical plan– Block A & E – Flat 1

3.1.1.2. TYPICAL FLOOR PLAN (BLOCK A & E)

- FLAT 2
- 3BHK – 1550 SQFT



Fig 3.4 Typical plan – Block A & E – Flat 2

3.1.1.3. TYPICAL FLOOR PLAN (BLOCK A & E)

- FLAT 3
- 3BHK – 1560 SQFT



Fig 3.5 Typical plan – Block A & E – Flat 3

3.1.1.4. TYPICAL FLOOR PLAN (BLOCK A & E)

- FLAT 4
- 3BHK – 1560 SQFT



Fig 3.6 Typical plan– Block A & E – Flat 4

3.1.1.5. TYPICAL FLOOR PLAN (BLOCK B & D)

- FLAT 1
- 2BHK – 1153 SQFT



Fig 3.7 Typical plan– Block B & D – Flat 1

3.1.1.6. TYPICAL FLOOR PLAN (BLOCK B & D)

- FLAT 2
- 2BHK – 1155 SQFT



Fig 3.8 Typical plan– Block B & D – Flat 2

3.1.1.7. TYPICAL FLOOR PLAN (BLOCK B & D)

- FLAT 3
- 2BHK – 1157 SQFT



Fig 3.9 Typical plan– Block B & D – Flat 3

3.1.1.8. TYPICAL FLOOR PLAN (BLOCK B & D)

- FLAT 4
- 2BHK – 1156 SQFT



Fig 3.10 Typical plan– Block B & D – Flat 4

3.1.1.9. TYPICAL FLOOR PLAN (BLOCK C)

- FLAT 1
- 3BHK – 1318 SQFT



Fig 3.11 Typical plan– Block C – Flat 1

3.1.1.10. TYPICAL FLOOR PLAN (BLOCK C)

- FLAT 2
- 3BHK – 1325 SQFT



Fig 3.12 Typical plan– Block C – Flat 2

3.1.1.11. TYPICAL FLOOR PLAN (BLOCK C)

- FLAT 3
- 3BHK – 1325 SQFT



Fig 3.13 Typical plan – Block C – Flat 3

3.1.1.12. TYPICAL FLOOR PLAN (BLOCK C)

- FLAT 4
- 3BHK – 1325 SQFT



Fig 3.14 Typical plan – Block C – Flat 4

3.1.1.13. MULTIPURPOSE HALL / CLUB HOUSE PLAN



Fig 3.15 Multipurpose hall

3.1.2. Scope selection



Fig 3.16. Block selected for Research

BLOCK NAME	A
FLAT NUMBERS	20
CONSTRUCTION STAGE	FIRST FLOOR
PROJECT BUILT-UP AREA	45,000 SQ. FT

Table 3.2 Block details

3.1.3. Work breakdown structure

- SUB STRUCTURE
- SUPER STRUCTURE
- INTERNAL FINISH

Block A
SUB STRUCTURE
Earth Work excavation for Footings
Dust filling & PCC for Footings
RCC Footings
RCC Columns up to Plinth
Back filling in foundation - 1st layer
Back filling in foundation - 2nd layer
Back filling up to Plinth Beam Bottom
Plinth Beam - Earth Work and Dust filling
Plinth Beam PCC Concrete
Plinth Beam
RCC Column in Basement
Brick work in Basement
Filling in plinth
Anti termite Treatment
Flooring PCC

Table 3.3 Sub Structure WBS

SUPER STRUCTURE	
Stilt Floor	
	RCC for Column
	Formwork for Roof Slab
	Rein. Work for Roof Slab
	Laying of Conduits. Inserts
	RCC for Roof Slab - GF
	Deshuttering
First Floor	
	RCC for Column
	Formwork for Roof Slab
	Rein. Work for Roof Slab
	Laying of Conduits. Inserts
	RCC for Roof Slab
	Deshuttering
Second Floor	
	RCC for Column
	Formwork for Roof Slab
	Rein. Work for Roof Slab
	Laying of Conduits. Inserts
	RCC for Roof Slab
	Deshuttering

ThirdFloor	
	RCC for Column
	Formwork for Roof Slab
	Rein. Work for Roof Slab
	Laying of Conduits. Inserts
	RCC for Roof Slab
	Deshuttering

Fourth floor
RCC for Column
Formwork for Roof Slab
Rein. Work for Roof Slab
Laying of Conduits. Inserts
RCC for Roof Slab
Deshuttering
Fifth floor
RCC for Column
Formwork for Roof Slab
Rein. Work for Roof Slab
Laying of Conduits. Inserts
RCC for Roof Slab
Deshuttering
Terrace Floor
RCC for Column for OHT / Head room
OHT BASE SLAB
OHT RCC WALLS
OHT COVER SLAB
HEAD ROOM ROOF SLAB

Table 3.4 Super structure WBS

FINISHING WORKS

Internal Finishes

Stilt Floor

Brick work including lintel & loft

Electrical wall chasing , Pipe & box fixing

Ceiling & Internal Plastering

Joineries by others

Flooring including toilets

Internal Painting

First Floor

Brick work including lintel & loft

Electrical wall chasing , Pipe & box fixing

Ceiling & Internal Plastering

Joineries by others

Flooring including toilets

Internal Painting

Second floor

Brick work including lintel & loft

Electrical wall chasing , Pipe & box fixing

Ceiling & Internal Plastering

Joineries by others

Flooring including toilets

Internal Painting

Third floor
Brick work including lintel & loft
Electrical wall chasing , Pipe & box fixing
Ceiling & Internal Plastering
Joineries by others
Flooring including toilets
Internal Painting
Fourth floor
Brick work including lintel & loft
Electrical wall chasing , Pipe & box fixing
Ceiling & Internal Plastering
Joineries by others
Flooring including toilets
Internal Painting
Fifth floor
Brick work including lintel & loft
Electrical wall chasing , Pipe & box fixing
Ceiling & Internal Plastering
Joineries by others
Flooring including toilets
Internal Painting
Terrace Floor
Parapet Wall
Head room wall & Plastering
Terrace Water proofing work
External Finishes
External Plastering
External development / Miscellaneous
Final Handing Over
Project Snagging & De-snagging

Table 3.5 Finishing Works WBS

REPETITIVE WORKS FROM WBS

TYPICAL ACTIVITIES – 5 Floors	
Super Structure	
	RCC for Column
	Formwork for Roof Slab
	Rein. Work for Roof Slab
	Laying of Conduits. Inserts
	RCC for Roof Slab
	Deshuttering
INTERNAL FINISHES	
	Brick work including lintel & loft
	Electrical wall chasing, Pipe & box fixing
	Ceiling & Internal Plastering
	Joineries by others
	Flooring including toilets
	Internal Painting

Table 3.6 Repetitive Activities

3.2. LINE OF BALANCE: SOFTWARE



Fig 3.17. Software Icon

- Powerproject is one of the project management software solutions for construction.
- Powerproject BIM is an integrated module for Powerproject which enables you to easily link the tasks in your project plan with 3D model components for 4D planning in one application. This makes it helpful for tendering and progress monitoring.

3.2.1. LINE OF BALANCE: Schedule Integration

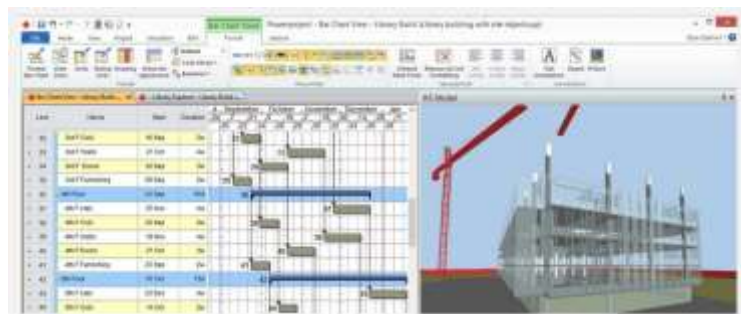


Fig 3.18. Software template figure



Fig 3.19. Sample Line of balance using Software

3.2.2. PLANNED SCHEDULE

4	SUB STRUCTURE	84 days	Mon 16-03-20	Sun 07-06-20
5	Earth Work excavation for Footings	15 days	Mon 16-03-20	Mon 30-03-20
6	Dust filling & PCC for Footings	15 days	Thu 19-03-20	Thu 02-04-20
7	RCC Footings	20 days	Tue 24-03-20	Sun 12-04-20
8	RCC Columns upto Plinth	15 days	Tue 31-03-20	Tue 14-04-20
9	Back filling in foundation	15 days	Tue 07-04-20	Tue 21-04-20
10	Plinth Beam	20 days	Wed 22-04-20	Mon 11-05-20
11	RCC Column in Basement	7 days	Tue 12-05-20	Mon 18-05-20
12	Brick work in Basement	10 days	Sun 17-05-20	Tue 26-05-20
13	Filling in plinth	10 days	Wed 27-05-20	Fri 05-06-20
14	Anti termite Treatment	5 days	Wed 03-06-20	Sun 07-06-20
15	Flooring PCC	5 days	Wed 03-06-20	Sun 07-06-20
16	SUPER STRUCTURE	217 days	Sat 06-06-20	Fri 08-01-21
17	Stilt Floor	40 days	Sat 06-06-20	Wed 15-07-20
18	RCC for Column	7 days	Sat 06-06-20	Fri 12-06-20
19	Formwork for Roof Slab	15 days	Sat 13-06-20	Sat 27-06-20
20	Rein. Work for Roof Slab	10 days	Sat 20-06-20	Mon 29-06-20
21	Laying of Conduits. Inserts	2 days	Mon 29-06-20	Tue 30-06-20
22	RCC for Roof Slab	1 day	Wed 01-07-20	Wed 01-07-20
23	Deshuttering	4 days	Sun 12-07-20	Wed 15-07-20
24	First Floor	47 days	Thu 02-07-20	Mon 17-08-20
25	RCC for Column	7 days	Thu 02-07-20	Wed 08-07-20
26	Formwork for Roof Slab	15 days	Thu 16-07-20	Thu 30-07-20
27	Rein. Work for Roof Slab	10 days	Thu 23-07-20	Sat 01-08-20
28	Laying of Conduits. Inserts	2 days	Sat 01-08-20	Sun 02-08-20
29	RCC for Roof Slab	1 day	Mon 03-08-20	Mon 03-08-20
30	Deshuttering	4 days	Fri 14-08-20	Mon 17-08-20
31	Second Floor	47 days	Tue 04-08-20	Sat 19-09-20
32	RCC for Column	7 days	Tue 04-08-20	Mon 10-08-20
33	Formwork for Roof Slab	15 days	Tue 18-08-20	Tue 01-09-20
34	Rein. Work for Roof Slab	10 days	Tue 25-08-20	Thu 03-09-20
35	Laying of Conduits. Inserts	2 days	Thu 03-09-20	Fri 04-09-20
36	RCC for Roof Slab	1 day	Sat 05-09-20	Sat 05-09-20
37	Deshuttering	4 days	Wed 16-09-20	Sat 19-09-20
38	Third Floor	47 days	Sun 06-09-20	Thu 22-10-20
39	RCC for Column	7 days	Sun 06-09-20	Sat 12-09-20
40	Formwork for Roof Slab	15 days	Sun 20-09-20	Sun 04-10-20
41	Rein. Work for Roof Slab	10 days	Sun 27-09-20	Tue 06-10-20

42	Laying of Conduits. Inserts	2 days	Tue 06-10-20	Wed 07-10-20
43	RCC for Roof Slab	1 day	Thu 08-10-20	Thu 08-10-20
44	Deshuttering	4 days	Mon 19-10-20	Thu 22-10-20
45	Fourth floor	47 days	Fri 09-10-20	Tue 24-11-20
46	RCC for Column	7 days	Fri 09-10-20	Thu 15-10-20
47	Formwork for Roof Slab	15 days	Fri 23-10-20	Fri 06-11-20
48	Rein. Work for Roof Slab	10 days	Fri 30-10-20	Sun 08-11-20
49	Laying of Conduits. Inserts	2 days	Sun 08-11-20	Mon 09-11-20
50	RCC for Roof Slab	1 day	Tue 10-11-20	Tue 10-11-20
51	Deshuttering	4 days	Sat 21-11-20	Tue 24-11-20
52	Fifth floor	47 days	Wed 11-11-20	Sun 27-12-20
53	RCC for Column	7 days	Wed 11-11-20	Tue 17-11-20
54	Formwork for Roof Slab	15 days	Wed 25-11-20	Wed 09-12-20
55	Rein. Work for Roof Slab	10 days	Wed 02-12-20	Fri 11-12-20
56	Laying of Conduits. Inserts	2 days	Fri 11-12-20	Sat 12-12-20
57	RCC for Roof Slab	1 day	Sun 13-12-20	Sun 13-12-20
58	Deshuttering	4 days	Thu 24-12-20	Sun 27-12-20
59	Terrace Floor	23 days	Thu 17-12-20	Fri 08-01-21
60	RCC for Column for OHT / Head room	4 days	Thu 17-12-20	Sun 20-12-20
61	OHT BASE SLAB	5 days	Mon 21-12-20	Fri 25-12-20
62	OHT RCC WALLS	10 days	Sat 26-12-20	Mon 04-01-21
63	OHT COVER SLAB	4 days	Tue 05-01-21	Fri 08-01-21
64	HEAD ROOM ROOF SLAB	7 days	Mon 21-12-20	Sun 27-12-20
65	FINISHING WORKS	261 days	Thu 16-07-20	Fri 02-04-21
66	Internal Finishes	225 days	Thu 16-07-20	Thu 25-02-21
67	Stilt Floor	50 days	Thu 16-07-20	Thu 03-09-20
68	Brick work including lintel & loft	10 days	Thu 16-07-20	Sat 25-07-20
69	Electrical wall chasing , Pipe & box fixing	2 days	Sun 26-07-20	Mon 27-07-20
70	Ceiling & Internal Plastering	20 days	Sun 26-07-20	Fri 14-08-20
71	Joineries by others	2 days	Sat 15-08-20	Sun 16-08-20
72	Flooring including toilets	15 days	Sat 15-08-20	Sat 29-08-20
73	Internal Painting	5 days	Sun 30-08-20	Thu 03-09-20
74	First Floor	60 days	Tue 18-08-20	Fri 16-10-20
75	Brick work including lintel & loft	35 days	Tue 18-08-20	Mon 21-09-20
76	Electrical wall chasing , Pipe & box fixing	26 days	Fri 28-08-20	Tue 22-09-20
77	Ceiling & Internal Plastering	30 days	Fri 28-08-20	Sat 26-09-20
78	Joineries by others	17 days	Sat 12-09-20	Mon 28-09-20
79	Flooring including toilets	25 days	Thu 17-09-20	Sun 11-10-20
80	Internal Painting	20 days	Sun 27-09-20	Fri 16-10-20
81	Second floor	60 days	Sun 20-09-20	Wed 18-11-20
82	Brick work including lintel & loft	35 days	Sun 20-09-20	Sat 24-10-20

83	Electrical wall chasing , Pipe & box fixing	26 days	Wed 30-09-20	Sun 25-10-20
84	Ceiling & Internal Plastering	30 days	Wed 30-09-20	Thu 29-10-20
85	Joineries by others	17 days	Thu 15-10-20	Sat 31-10-20
86	Flooring including toilets	25 days	Tue 20-10-20	Fri 13-11-20
87	Internal Painting	20 days	Fri 30-10-20	Wed 18-11-20
88	Third floor	60 days	Fri 23-10-20	Mon 21-12-20
89	Brick work including lintel & loft	35 days	Fri 23-10-20	Thu 26-11-20
90	Electrical wall chasing , Pipe & box fixing	26 days	Mon 02-11-20	Fri 27-11-20
91	Ceiling & Internal Plastering	30 days	Mon 02-11-20	Tue 01-12-20
92	Joineries by others	17 days	Tue 17-11-20	Thu 03-12-20
93	Flooring including toilets	25 days	Sun 22-11-20	Wed 16-12-20
94	Internal Painting	20 days	Wed 02-12-20	Mon 21-12-20
95	Fourth floor	60 days	Wed 25-11-20	Sat 23-01-21
96	Brick work including lintel & loft	35 days	Wed 25-11-20	Tue 29-12-20
97	Electrical wall chasing , Pipe & box fixing	26 days	Sat 05-12-20	Wed 30-12-20
98	Ceiling & Internal Plastering	30 days	Sat 05-12-20	Sun 03-01-21
99	Joineries by others	17 days	Sun 20-12-20	Tue 05-01-21
100	Flooring including toilets	25 days	Fri 25-12-20	Mon 18-01-21
101	Internal Painting	20 days	Mon 04-01-21	Sat 23-01-21
102	Fifth floor	60 days	Mon 28-12-20	Thu 25-02-21
103	Brick work including lintel & loft	36 days	Mon 28-12-20	Mon 01-02-21
104	Electrical wall chasing , Pipe & box fixing	26 days	Thu 07-01-21	Mon 01-02-21
105	Ceiling & Internal Plastering	30 days	Thu 07-01-21	Fri 05-02-21
106	Joineries by others	17 days	Fri 22-01-21	Sun 07-02-21
107	Flooring including toilets	25 days	Wed 27-01-21	Sat 20-02-21
108	Internal Painting	20 days	Sat 06-02-21	Thu 25-02-21
109	Terrace Floor	45 days	Mon 28-12-20	Wed 10-02-21
110	Parapet Wall	10 days	Mon 28-12-20	Wed 06-01-21
111	Head room wall & Plastering	15 days	Mon 28-12-20	Mon 11-01-21
112	Terrace Water proofing work	30 days	Tue 12-01-21	Wed 10-02-21
113	External Finishes	60 days	Tue 02-02-21	Fri 02-04-21
114	External Plastering	40 days	Tue 02-02-21	Sat 13-03-21
115	External development / Miscellaneous	20 days	Sun 14-03-21	Fri 02-04-21
116	Final Handing Over	3 days	Sat 03-04-21	Mon 05-04-21
117	Project Snagging & De-snagging	3 days	Sat 03-04-21	Mon 05-04-21

Table 3.7 Actual Planned Schedule

3.2.3. Excel sheet - line graph - super structure civil works

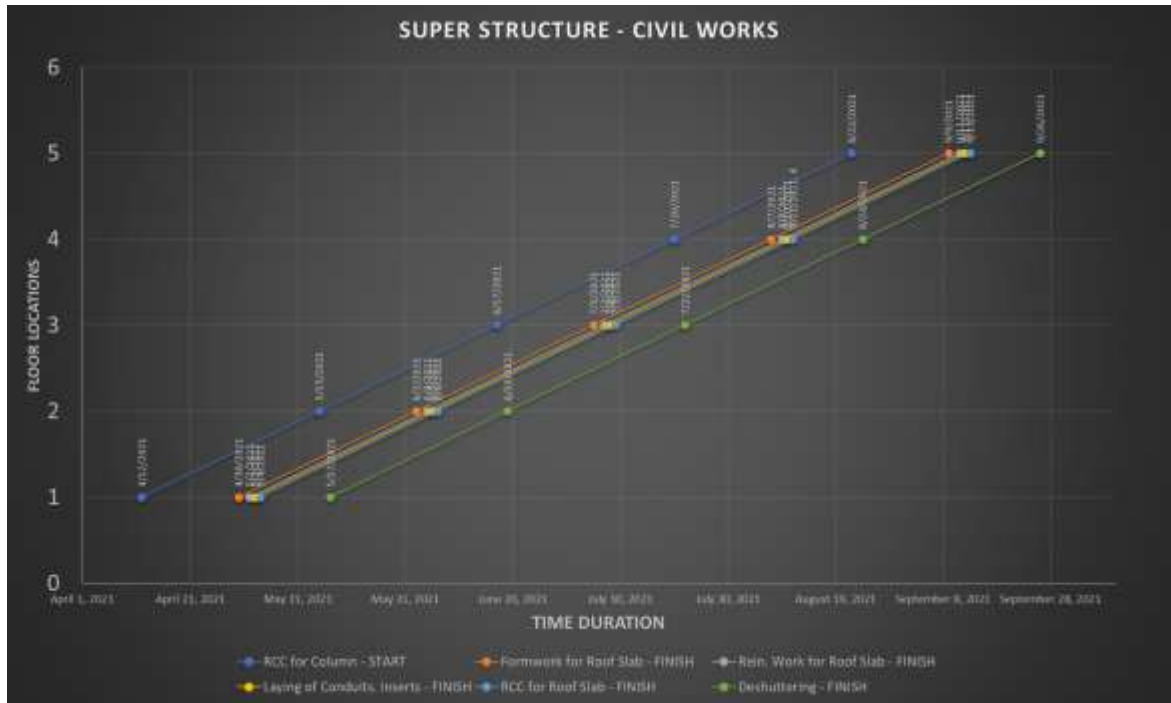


Fig 3.20. Line Graph – Super Structure Civil Works

3.2.4. Line graph - finishing works

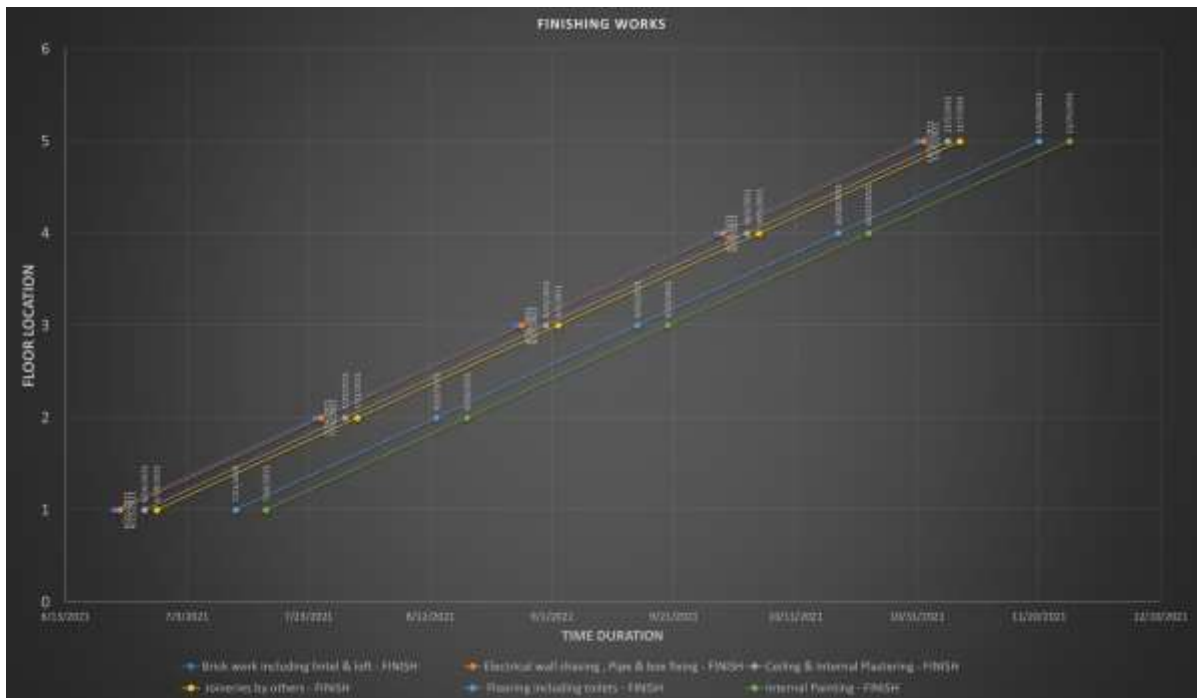


Fig 3.21. Line Graph – Super Structure Finishing Works

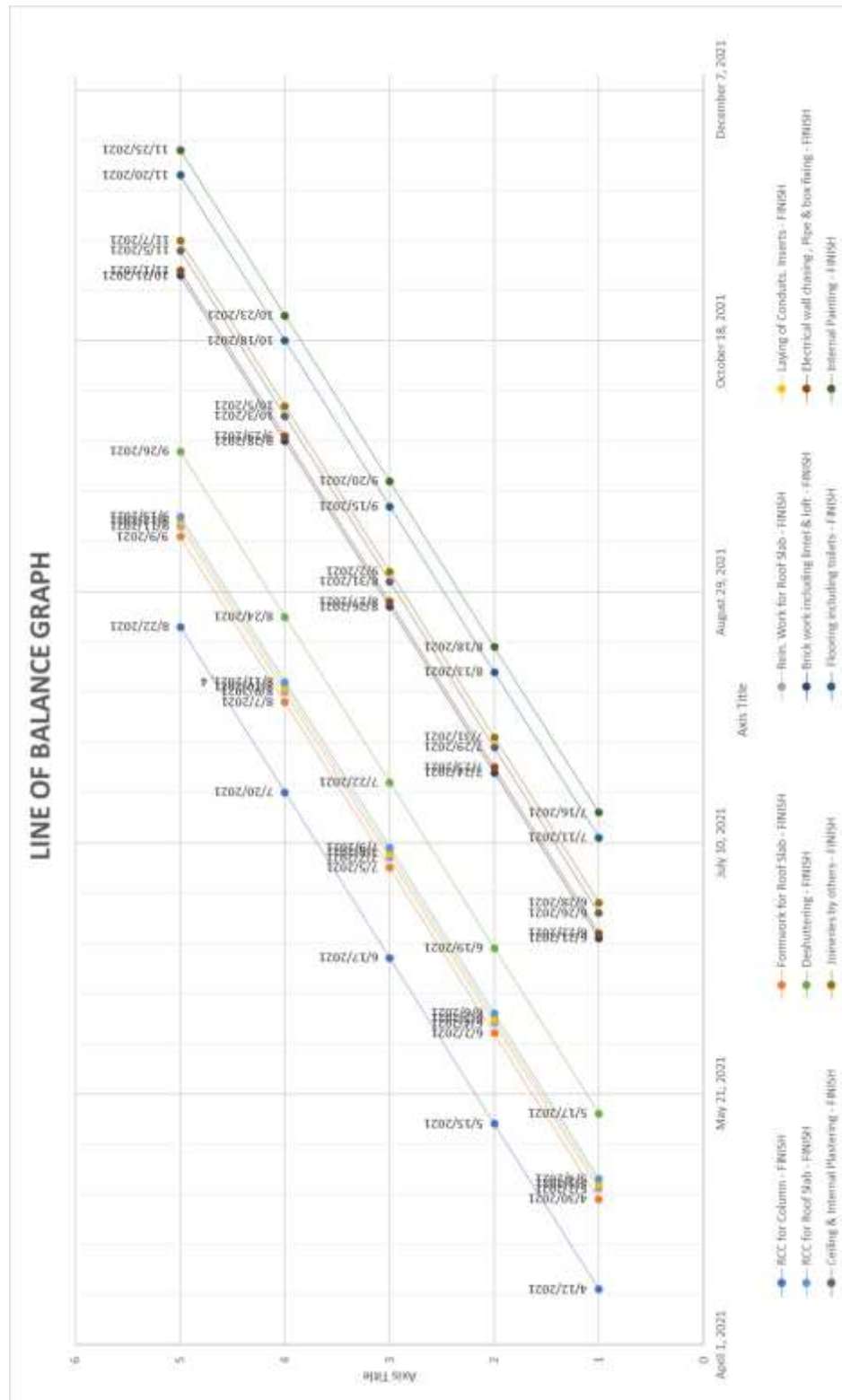


Fig 3.22. Overall Line Graph using Excel

3.3. Powerproject – BIM

3.3.1. Schedule

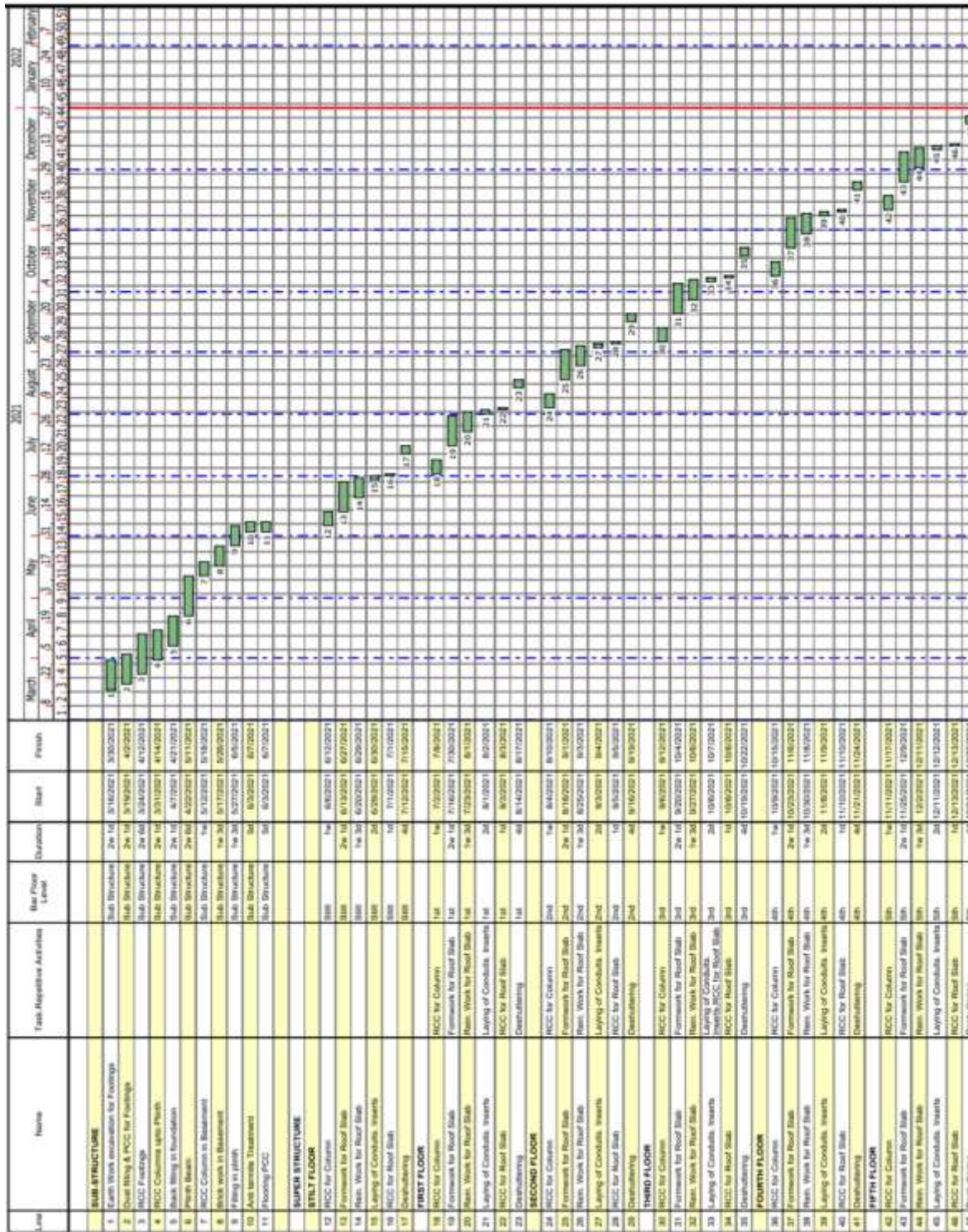


Fig 3.10. BIM Schedule

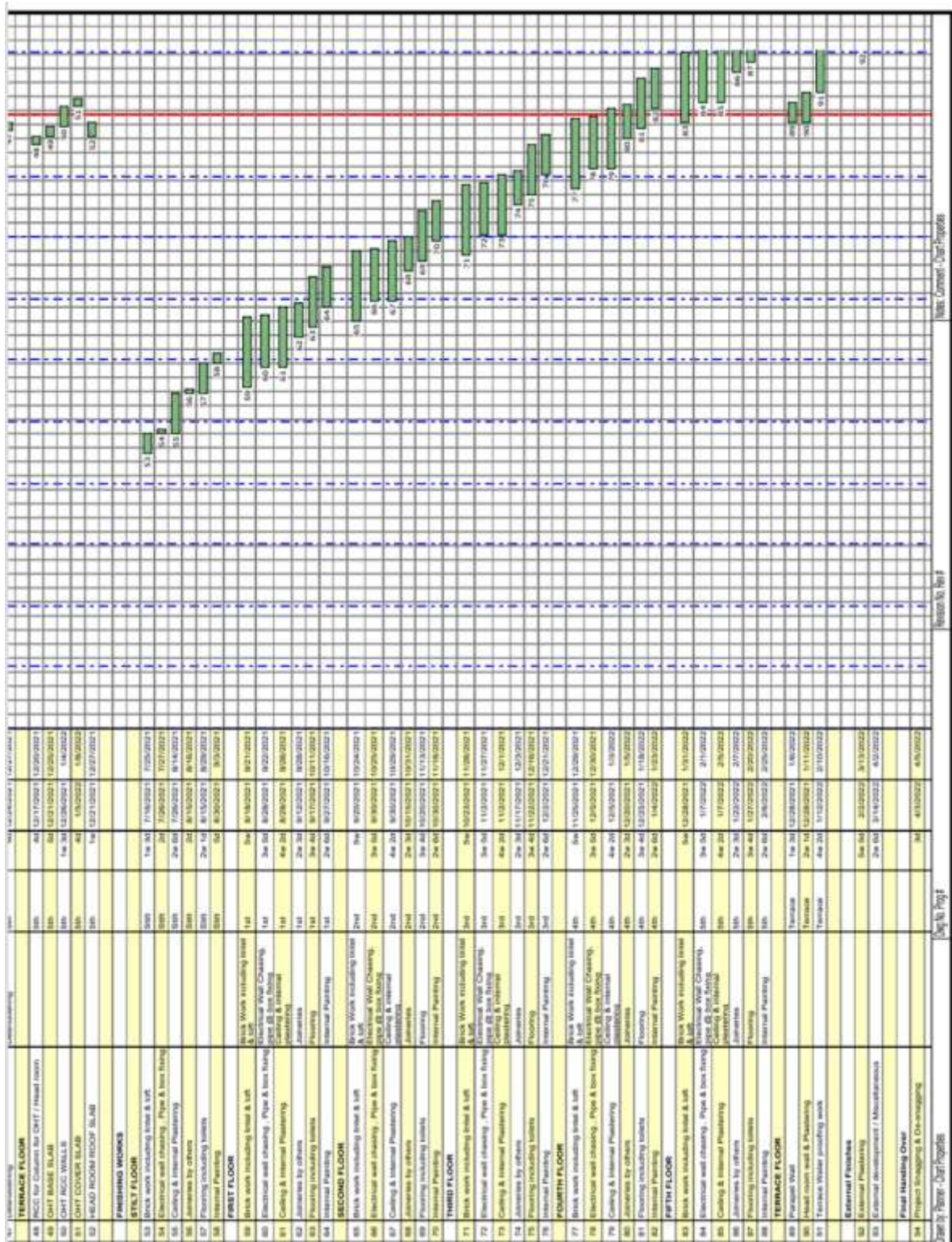


Fig 3.23. BIM Schedule

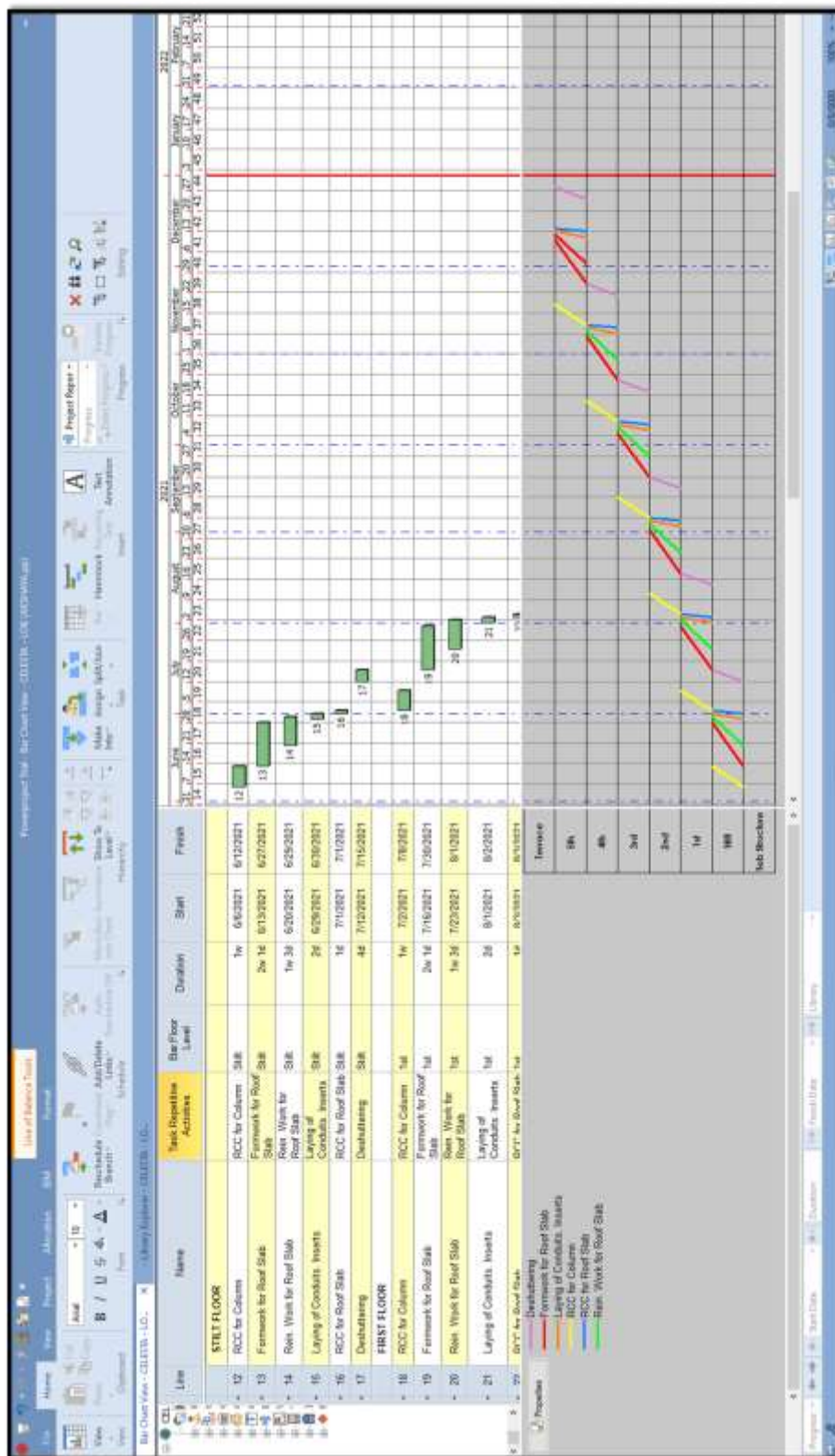


Fig 3.24. Powerproject BIM - Line graph –Civil works

3.3.2. Line graph – repetitive floor civil works & finishing works

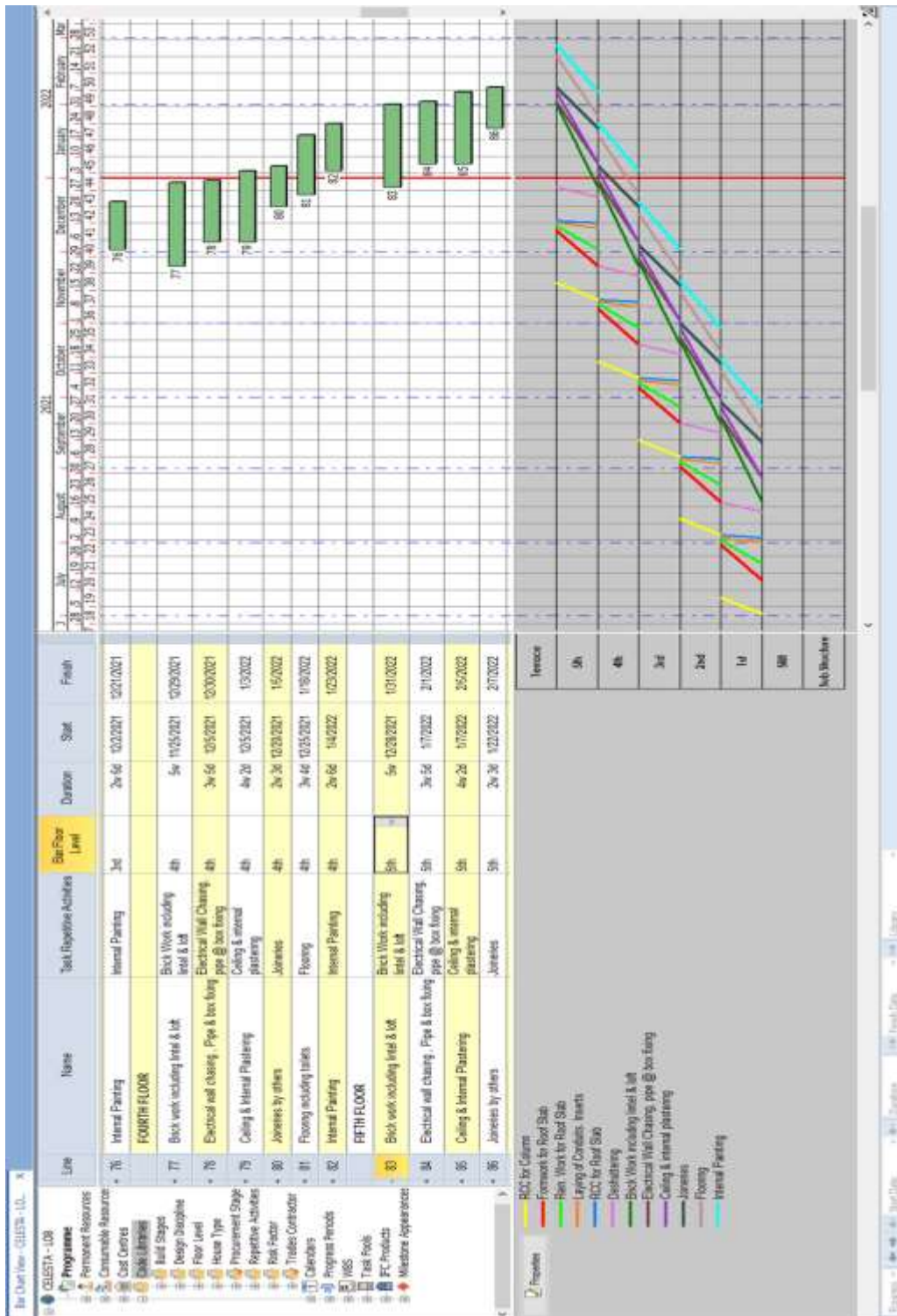


Fig 3.25. Powerproject BIM - Line graph –Civil works & finishing works

3.3.3. Line graph – repetitive floor civil works & internal finishing works

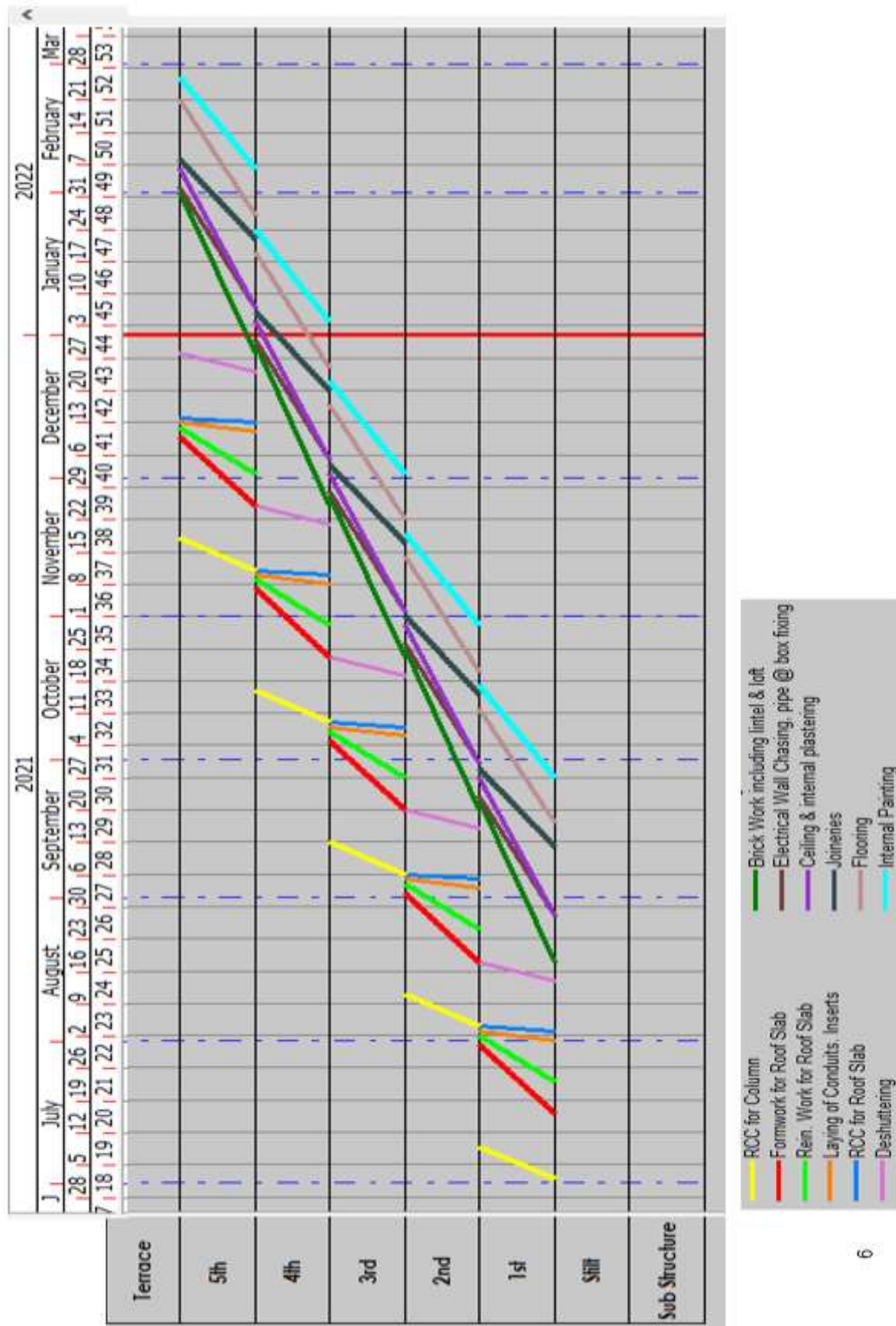


Fig 3.26. Powerproject BIM - Line graph –Civil works & finishing works - Output

3.3.5. Line graph – repetitive floor civil works & internal finishing works – painting work

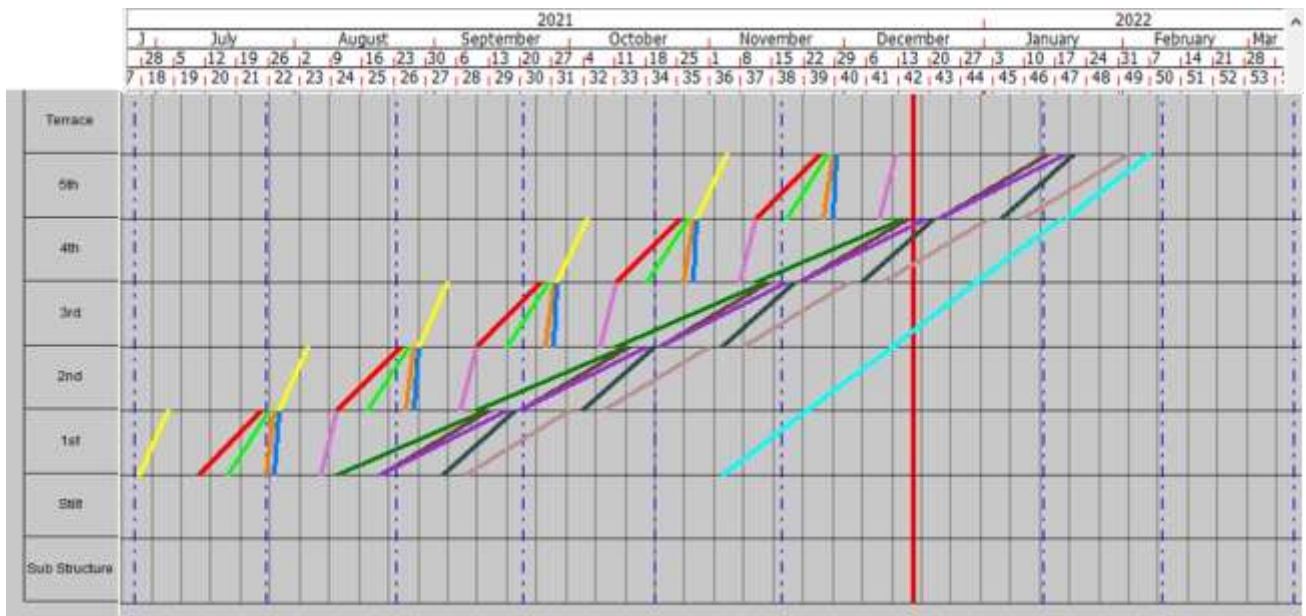
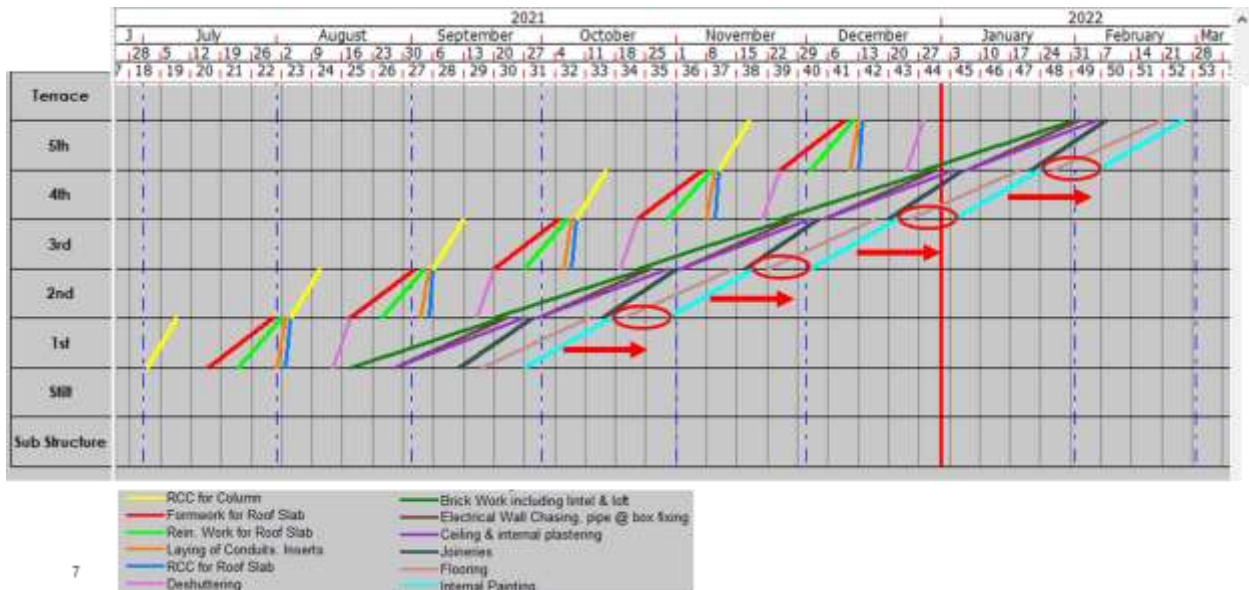


Fig 3.27. Powerproject BIM - Line graph –Civil works & finishing works – Painting Works

- Finish Time retaining the same, Buffer zone has been eliminated and work continuity has been improvised.
- This helps the Internal painting crew to have continuous works without any lag or time gap.

3.3.6. Line graph – repetitive floor civil works & internal finishing works – flooring work

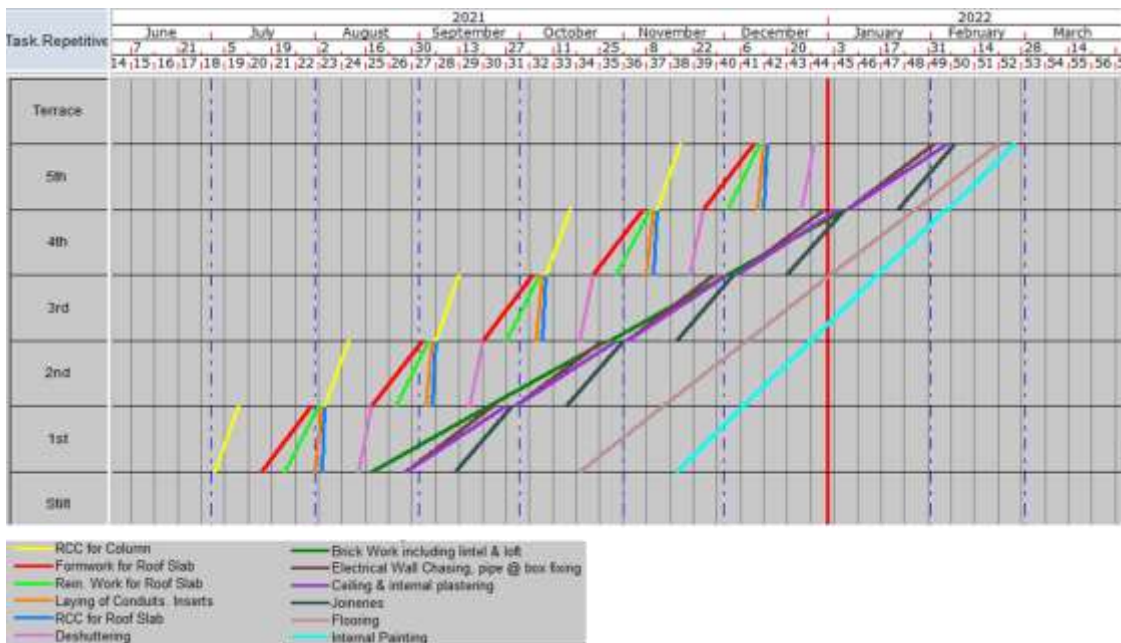
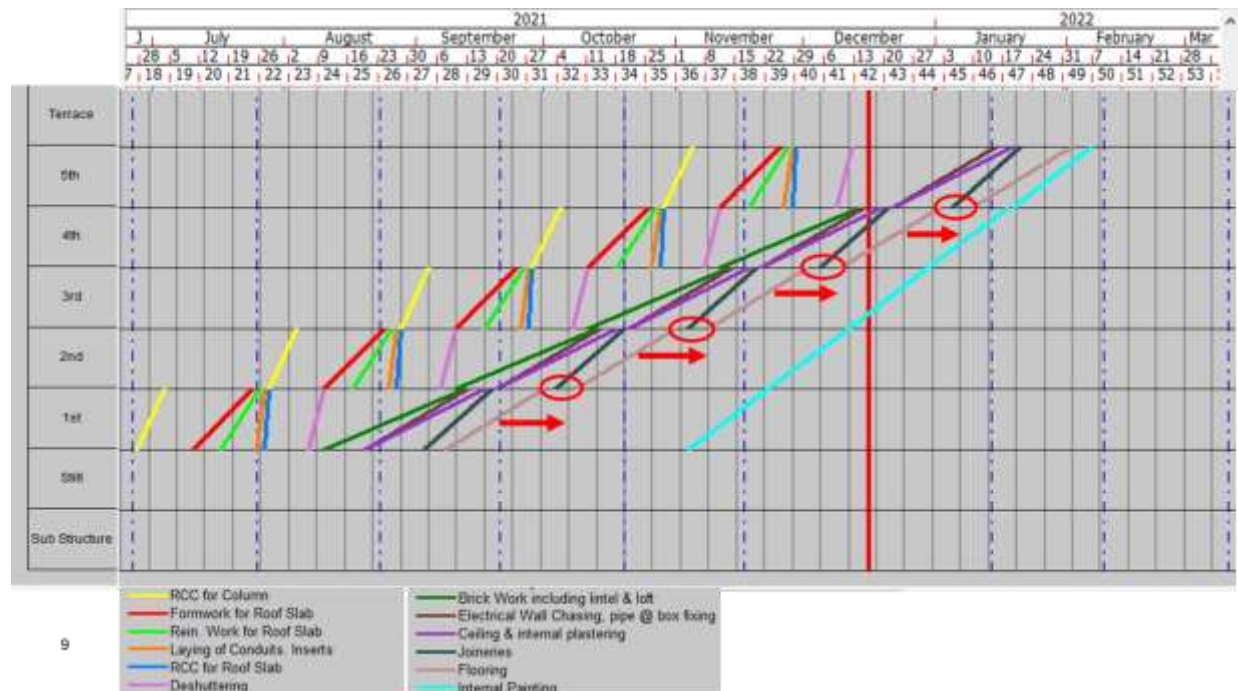


Fig 3.28. Powerproject BIM - Line graph –Civil works & finishing works – Flooring works

3.3.7. Line graph – repetitive floor civil works & internal finishing works – joineries

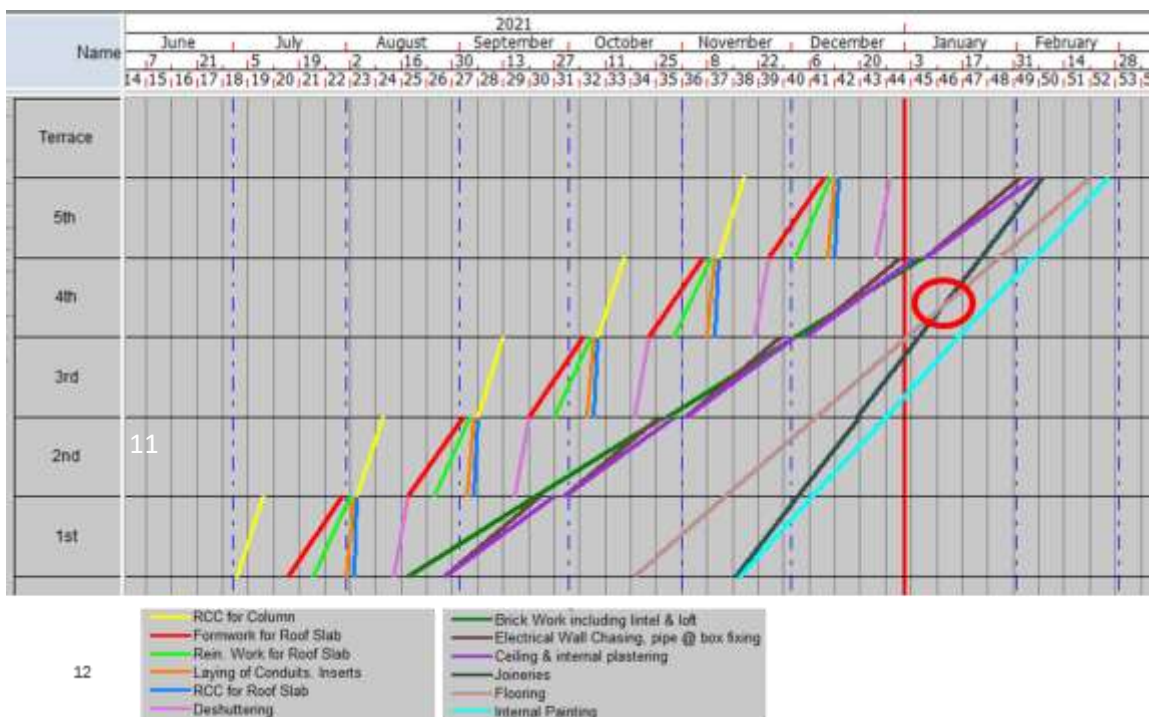
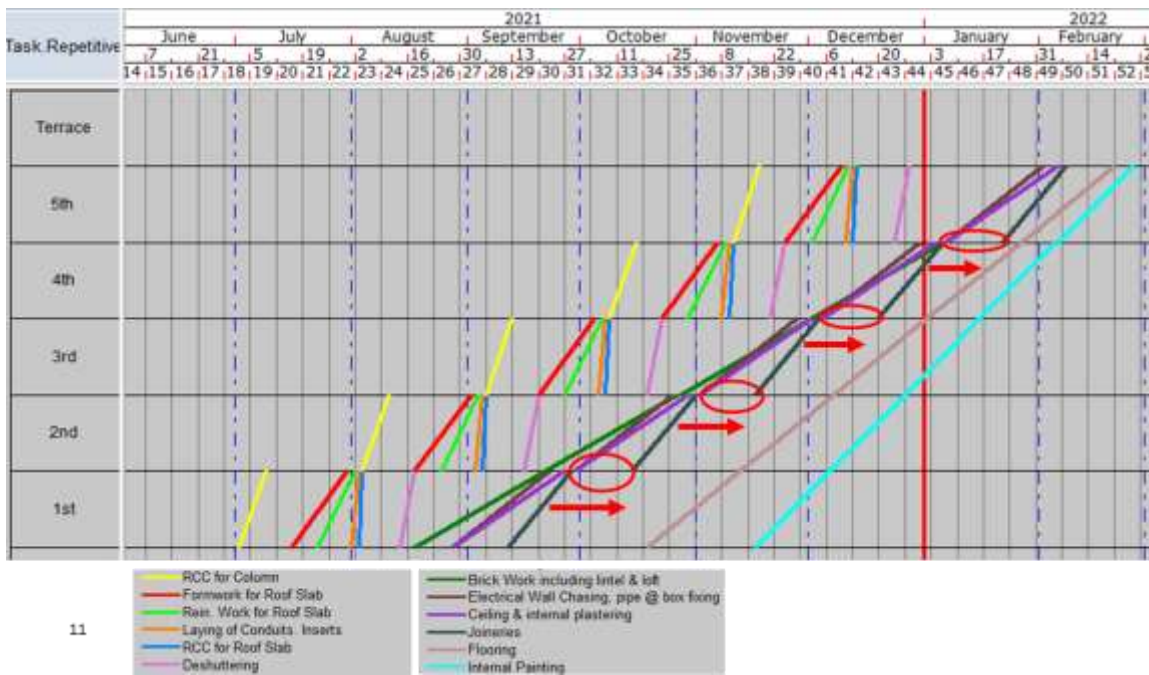


Fig 3.29. Powerproject BIM - Line graph –Civil works & finishing works – Flooring works

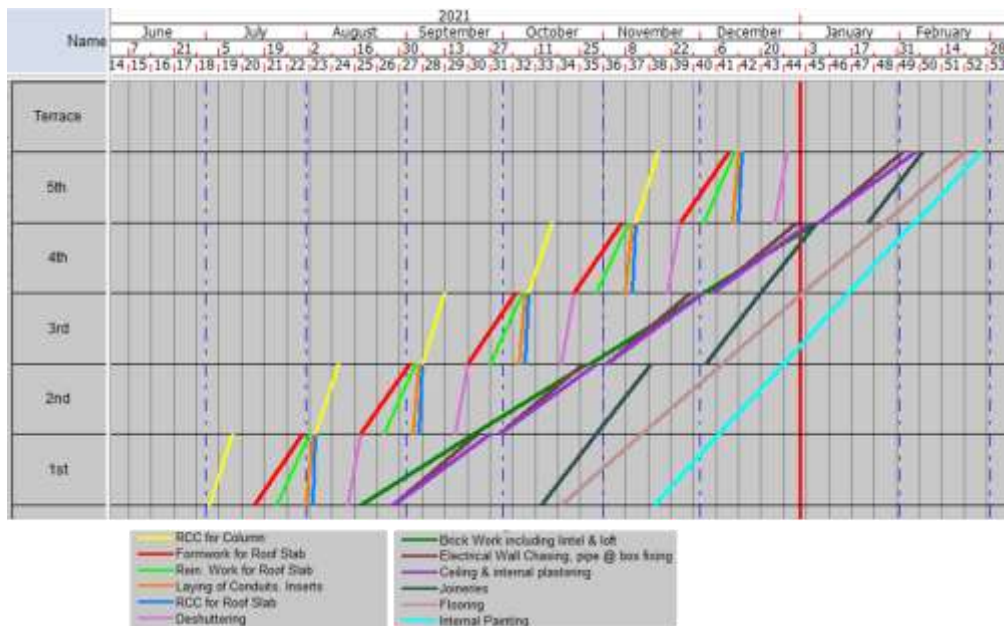
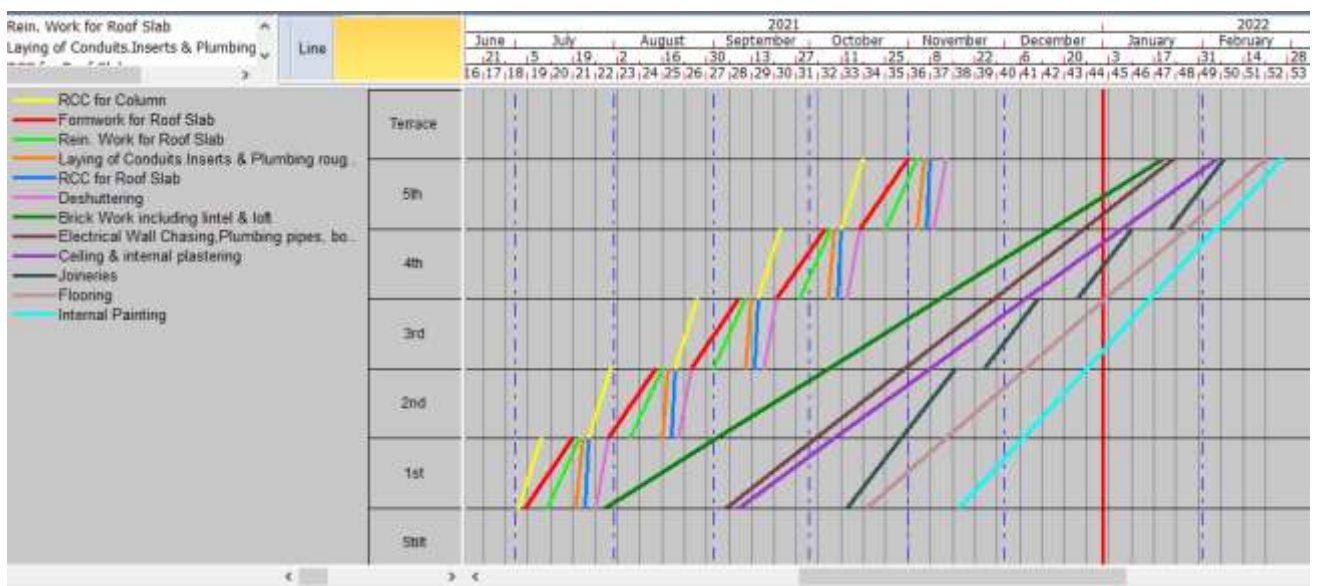


Fig 3.30. Powerproject BIM - Line graph –Civil works & finishing works – Flooring works

- Finish Time retaining the same, Buffer zone has been eliminated.
- The problem here is that flooring and joinery work gets intersected.

3.3.8. Line graph – repetitive floor civil works & internal finishing works – optimized output



3.3.9. Line graph – repetitive floor civil works & internal finishing works – overall output

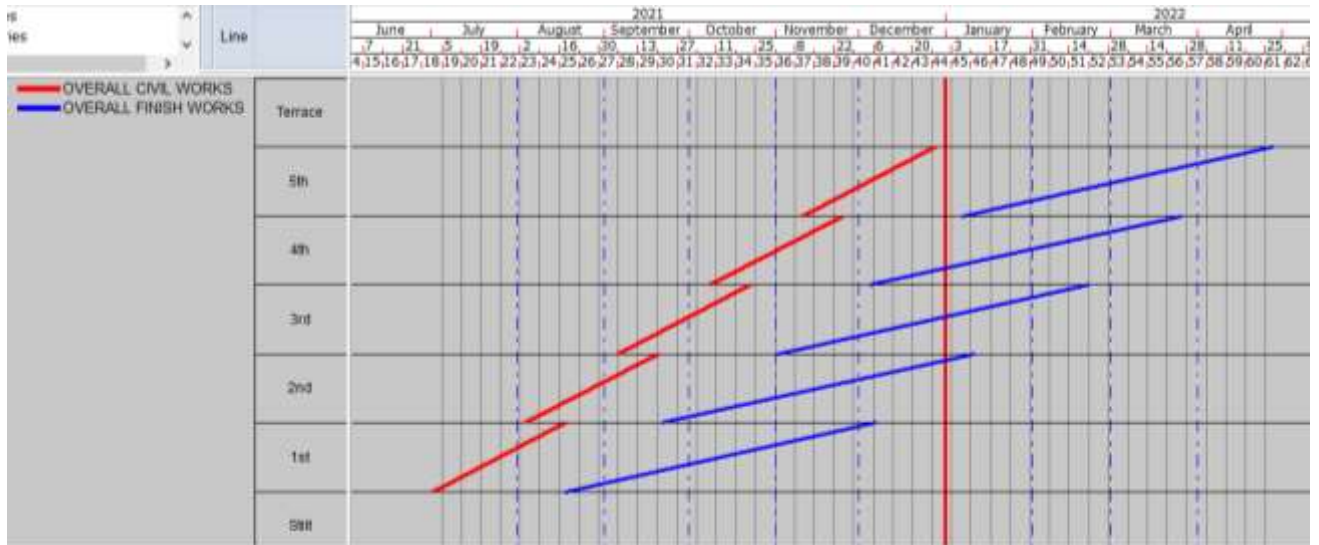


Fig 3.31. Actual schedule graph

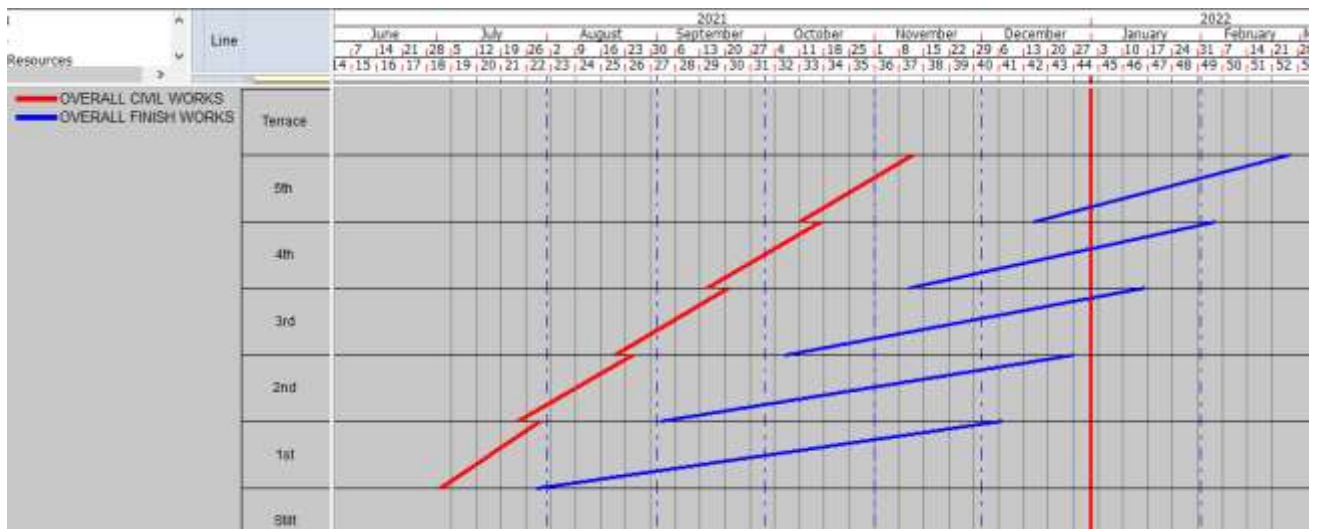


Fig 3.32. Optimized schedule graph

3.4. OPTIMIZED SCHEDULE:

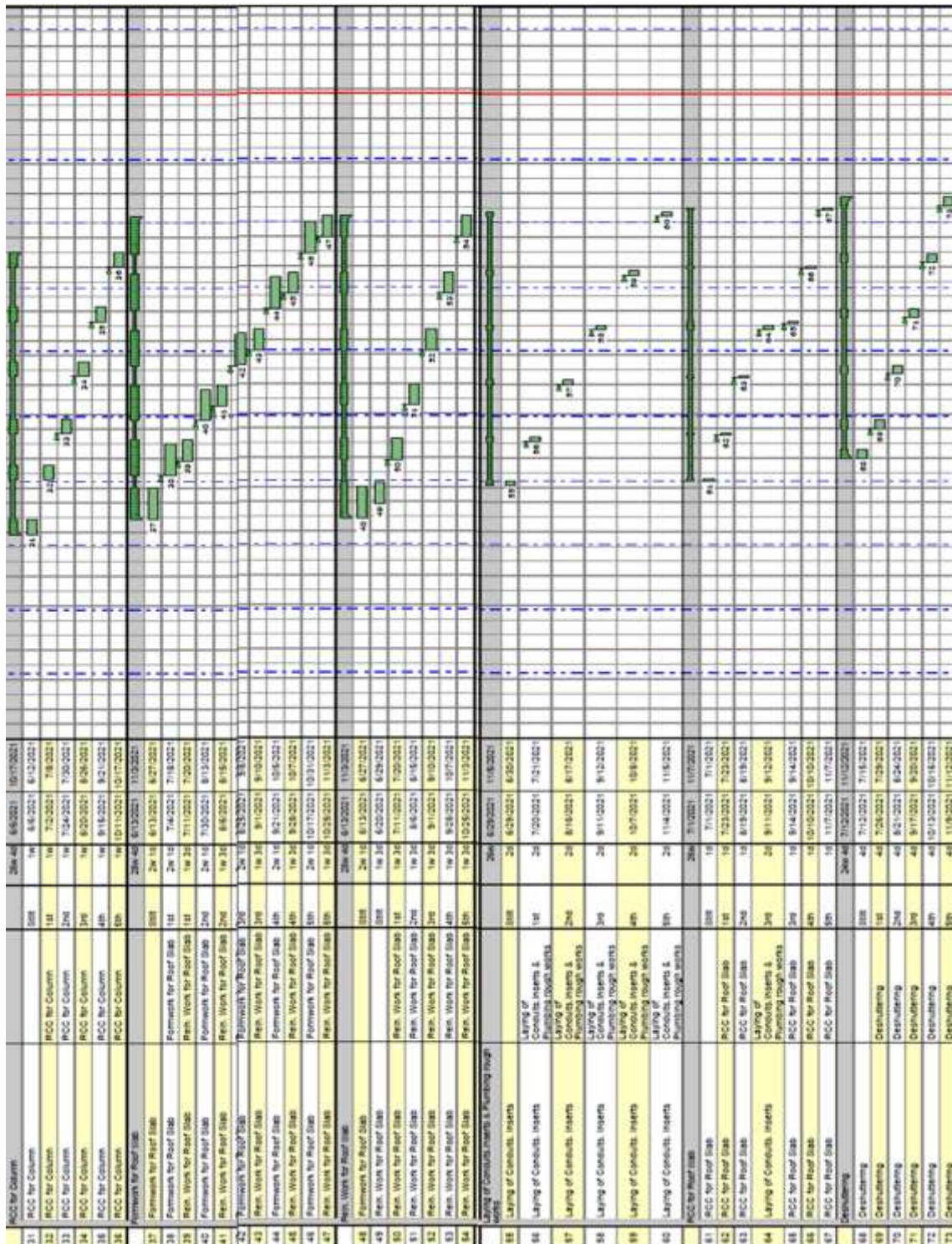


Fig 3.33. Optimized BIM schedule

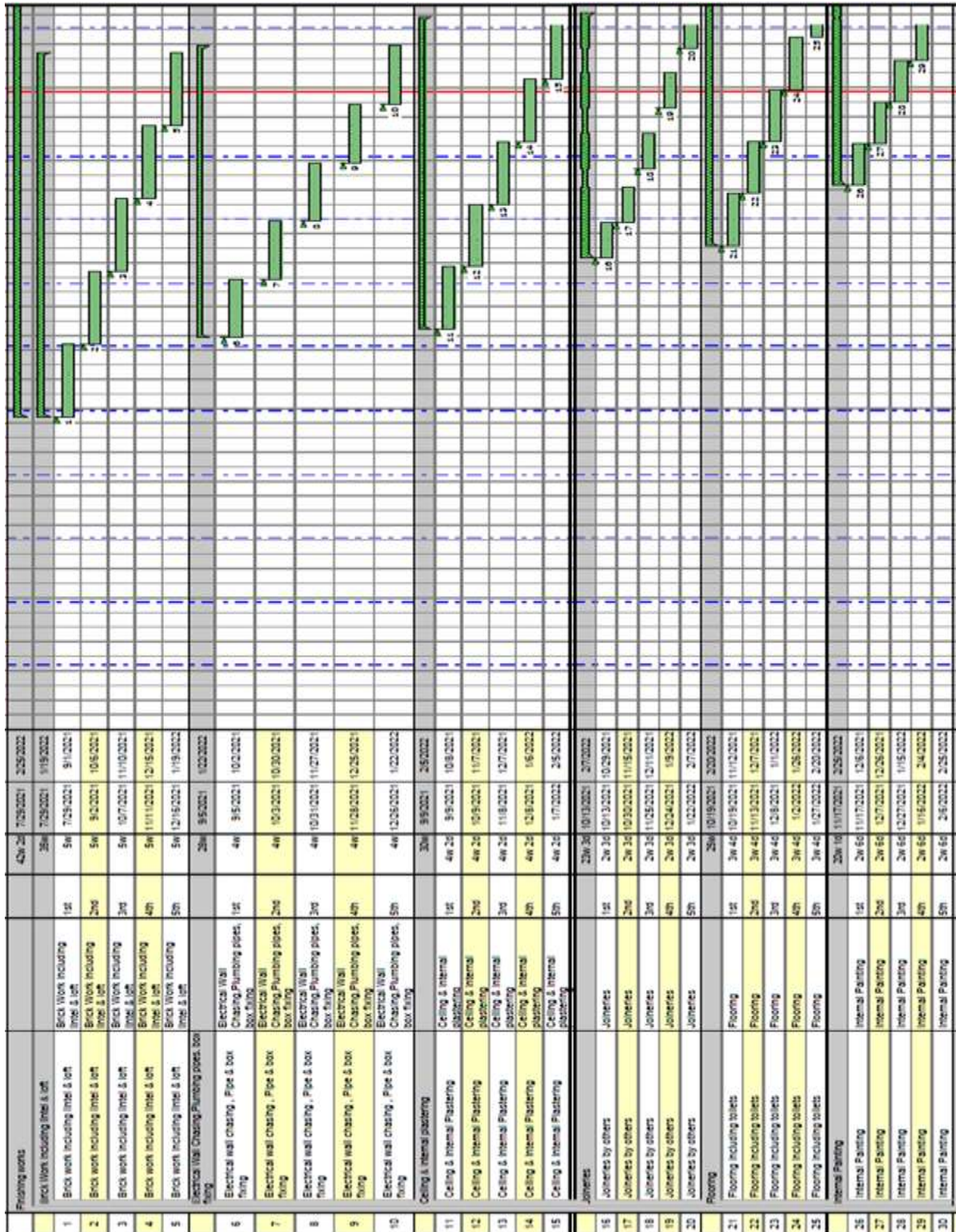


Fig 3.34. Optimized BIM schedule

CHAPTER 4

CONCLUSION

4.1. RESULTS

- For the finishing works keeping the finish time same, the work flow continuity has been optimized. By this the labor crew work is also optimized correspondingly.
- Line of balance method is effective in finding out FLOWLINE of the Tasks and activities.
- Implementation of Elecosoft PowerProject BIM software helps in planning and visualizing in effective way in planning and scheduling of activities in each location.

4.2. CONCLUSION

- In this research, the objective is to study and implement the LOB method and Elecosoft Powerproject BIM tool for the calculations of total project duration of Midrise residential building.
- According to the result the better optimization for the scheduling of project is been done from LOB and Powerproject BIM tool for the calculation of flow line of project progress.
- LOB method and Powerproject BIM tool are a graphical representation of repetitive activities where project manager can analyze the flowline by which project manager can take suitable action over progress.

4.3. FUTURE RESEARCH

Analysis on

- Locations
- Task continuity
- Visualizing dependencies
- Optimization of program
- Movement of crews
- Production rate

REFERENCES

- Arditi, D., Sikangwan, P., & Tokdemir, O. B. (2002). Scheduling system for high rise building construction. *Construction Management & Economics*, 20(4), 353-364.
- Hyari, K., & El-Rayes, K. (2006). Optimal planning and scheduling for repetitive construction projects. *Journal of Management in Engineering*, 22(1), 11-19.
- Damci, A., Arditi, D., & Polat, G. (2013). Multiresource leveling in line-of-balance scheduling. *Journal of Construction Engineering and Management*, 139(9), 1108-1116.
- da Rocha, C. G., & Kemmer, S. L. (2013). Method to implement delayed product differentiation in construction of high-rise apartment building projects. *Journal of construction engineering and management*, 139(10), 05013001.
- Damci, A., Arditi, D., & Polat, G. (2016). Impacts of different objective functions on resource leveling in line-of-balance scheduling. *KSCE journal of civil engineering*, 20(1), 58-67.
- Cheng, B. (2005). *Limitations of Existing Scheduling Tools in Planning Utility Line Construction Projects* (Doctoral dissertation, University of Florida).
- Suhail, S. A., & Neale, R. H. (1994). CPM/LOB: New methodology to integrate CPM and line of balance. *Journal of Construction Engineering and Management*, 120(3), 667-684.
- Frandsen, A. G., Seppänen, O., & Tommelein, I. D. (2015, July). Comparison between location-based management and takt time planning. In *Proceedings of the 23rd Annual Conference of the International Group for Lean Construction* (pp. 28-31). Perth: IGLC.
- Shankar, A., & Varghese, K. (2013). Evaluation of location-based management system in the construction of power transmission and distribution projects. In *ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction* (Vol. 30, p. 1). IAARC Publications.
- Soini, M., Leskelä, I., & Seppänen, O. (2004, August). Implementation of line-of-balance based scheduling and project control system in a large construction company. In *12th Annual conference of Lean Construction*.
- Bhushan, R. S., & Raghavan, S. V. (2013). A relative study on CCPM and LOB Scheduling Technique. *Indian Journal of Applied Research*, 3(5), 242-245.
- Lutz, J. D., & Hijazi, A. (1993). Planning repetitive construction: Current practice. *Construction management and economics*, 11(2), 99-110.