

ENHANCING PLANNING STAGE OF CONSTRUCTION USING LEAN PROJECT MANAGEMENT SYSTEM

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
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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

MAY 2021



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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **MONISHA NAGESWARAN (39840021)** who carried out the Thesis entitled “**ENHANCING PLANNING STAGE OF CONSTRUCTION USING LEAN PROJECT MANAGEMENT SYSTEM**” under our supervision from January 2021 to May 2021.

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ABSTRACT

According to Lean Construction Institute nearly 70% of the project suffers from time and cost overrun due to ineffective conventional project planning system for fast, complex, dynamic and uncertain project with multiple stakeholders, leading to compromisation of the project and no value is generated to the client.

Hence it requires a strong, value generating & commitment based project planning system such as lean based planning system to complete the construction with in stipulated time and cost.

The study involves qualitative research such as participation and observation of case study and face to face interview and secondary study to identify the drawbacks of conventional planning system in terms of time overrun during construction stage - Civil core and their impact on project performance. And develop a framework as a solution using lean concept for lean project planning system to enhance the project performance during civil core construction.

Keywords: Lean Project Management, Last Planner System, Construction Project Planning, Conventional PM System, Collaboration, Time Management, Planning, Scheduling and Tracking

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LIST OF SYMBOLS AND ABBREVIATIONS

LPS	-	Last Planner System
LCI	-	Lean Construction Institute
CPM	-	Critical Path Method
PDCA	-	Plan Do Check Act
PPC	-	Percentage Project Completion
RPS	-	Reverse Phase Schedule
SWLA	-	Six Weeks Look Ahead Schedule
WWP	-	Weekly Work Plan
FRS	-	First Run Studies
PMC	-	Project Management Consultant
DC	-	Design Consultant
PEB	-	Pre- Engineered Building
RCC	-	Reinforced Cement Concrete
PM	-	Project Manager
BIM	-	Building Information Model
DB	-	Design Built
CBA	-	Choosing By Advantage
IPD	-	Integrated Project Delivery Model
DB	-	Design Built
URD	-	User Requirement Document
GC	-	General Contractor

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Construction planners supervise the method of mental imagery a completed building and dealing backward to work out a way to complete it. Construction coming up with involves distinguishing all the desired steps to make a structure, cacophonous them into outlined activities, ordering these steps logically, and decide the required materials, manpower, and instrumentation. If you don't have a powerful set up, the probability of getting a no-hit construction project decreases dramatically. The analysis includes finding out methodology of implementing typical and Lean Project Management System throughout Construction Stage along side analyzing the challenges faced by typical Project Management System along side a Case Study throughout Construction Stage for Civil Substructure work for PEB Building and their needed Aspirations and supply answer exploitation Last Planner System as a Lean Technique for Construction coming up with along side methodology of Implementation and LPS Templates for Implementation.

Construction coming up with is that the 1st stage of construction management, the discipline of taking a construction project from conception to completion. Construction management includes many alternative parts that succeed coming up with, however: programing is deciding once to start out, execute, and complete every task. Organizing is obtaining all the moving items in position to perform every task. Staffing is assignment individuals to duties associated with the project. leading is guaranteeing that you just complete tasks as planned, and observance is guaranteeing that you just meet the wants and performance benchmarks set throughout the design stage. If you don't meet these necessities, you'll devote respectable time to the dominant stage, that involves managing the budget and meeting contract necessities.

Since humans are constructing buildings for thousands of years, construction coming up with is Associate in Nursing ancient discipline. we will trace some style of construction project coming up with all the approach back to the Neolithic amount, once builders in Western Europe were erection Stonehenge.

Today, the tools, techniques, and instrumentation that builders use have modified, however coming up with remains Associate in Nursing integral a part of the development management method. whereas construction coming up with is time overwhelming, the advantages greatly outweigh the prices. A 1994 study by the development business Institute (CII) found a "positive, quantitative relationship between efforts gone throughout the pre-project coming up with section and also the final success of a project."

To be effective, you ought to approach construction coming up with with logic, painstakingness, and honesty. you may want information and knowledge in construction strategies and catching, Associate in Nursing planners should visualize the tasks and activities and perceive the relationships between them so they will carry them get in an economical sequence.

1.1.1 Failure Reasons of Conventional Construction Planning System

1. Time and value overrun, lack of extra worth & Scope creep
2. Schedules centering on long durations fail to handle Uncertainties / Variables & the issues which require micro-duration schedules with the next level of detail and numerous uncertainties. They're reactive in nature & not proactive and that they lack continuous learning and determination issues from root cause.
3. The programing (dates & duration) & coming up with of the project ar determined by a couple of people that aren't involved the every day task. wherever they address the project as an entire, not in pieces/parts. rather than programing for a project extensively, we should always create milestones primarily based schedules for every restricted amount/ a pair of – six week period, half to whole approach.
4. The current construction management mechanism lacks commitment, answerability between stakeholders, Lack of collaboration between them, Leading to lack of cooperation, ineffective communication & coordination, mistaking, Lack of understanding of interdependencies between every stakeholder's delivery & every one's demand ends up in lag from original schedule & coming up with.
5. Lack of structured flow of knowledge pattern for style section & continuous improvisation of the project.
6. Lack of human-centric approach. Lack of equal importance to value & flow management Compared to transformation management.
7. Absence of mechanism to trace stakeholder's work progress, info flow, Reminders & Alarms for response ends up in delay of project delivery.
8. There's a requirement for a mechanism for all stakeholders to grasp the project and its progress and maintain all of them at same section.

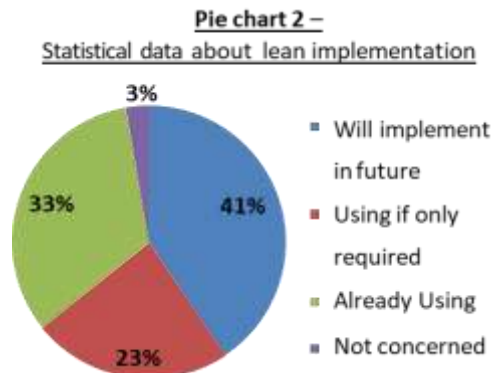
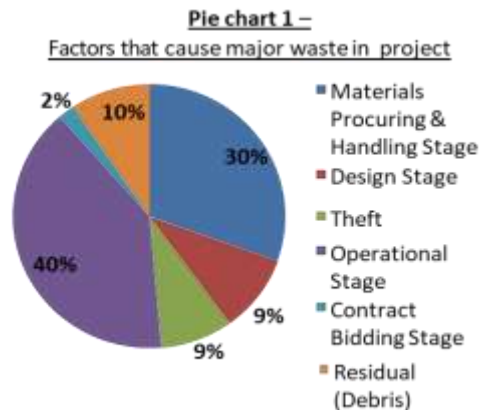


Fig 1.1 Major Waste in Project due to Conventional PM System & Awareness of Lean

1.1.2 Lean Construction versus Traditional CPM Approach

Lean approach is additional economical on advanced comes with dynamic nature & high uncertainties. Here are a number of the distinction between the Lean Construction & the standard project management approach (Sicat 2012):

1. The role of management in lean is to assure reliable progress in contrary to ancient methodology that takes corrective action once detective work variances.
2. The most target of the lean approach is to maximise worth by up the entire method however within the ancient methodology optimisation is for every activity severally.
3. Lean could be a pull – driven approach whereas ancient is push-driven approach.
4. Reducing variations at early stages is one among the most aims of lean thinking whereas within the ancient approach it's not thought-about.

1.2 AIM OF THE PROJECT

To implement Lean Construction conception to the traditional construction project coming up with system to beat their drawbacks and improve the project performance throughout construction stage.

1.3 OBJECTIVE OF THE PROJECT

1. Analyze Current Application and Awareness of Lean Construction Management System in Indian housing industry throughout style Stage.
2. Identification of drawbacks faced by the traditional Construction Project coming up with approach and distinguishing their root cause and aspiration from project manager, contractor, style authority and homeowners perspective.
3. Developing frameworks & templates exploitation lean conception and techniques for construction project coming up with method so as to enhance the development method performance.
4. Implementing the frame work on a case study to examine its relevance and impact of lean over typical system on project performance throughout construction.

1.4 SCOPE & LIMITATIONS OF THE PROJECT

1. Project coming up with method for construction part - Civil Core, to live project in Time whereas implementing standard project coming up with system and lean coming up with system.
2. To develop lean primarily based construction project coming up with framework to enhance project performance throughout construction stage - Civil core by economical time management.

1.5 RESEARCH METHODOLOGY



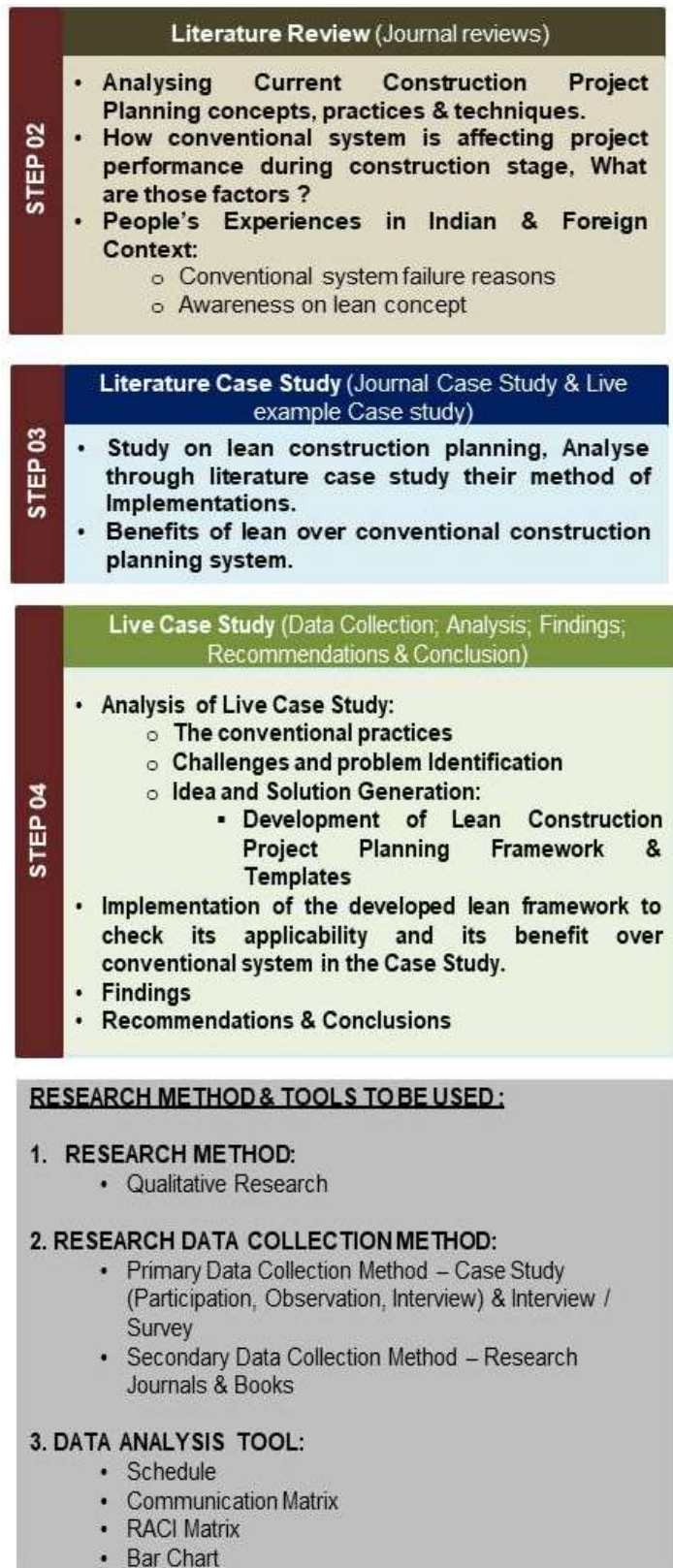


Fig 1.2 Research Methodology

Table 1.1 Literature & Live Case Study Content

LITERATURE & LIVE STUDY	
TYPOLOGY	TITLE
Research Paper	Journal 1: Mcgraw Hill Construction Lean Construction – Leveraging Collaboration & Advanced Practices To Increase Project Efficiency. Journal 2: Traditional Project Management Approach, Industry Challenges And Key Attributes: A Case Study Of Construction Project Management In Sri Lanka – Asian Pacific Journal Of Advanced Business & Social Studies – Year 2019 Journal 3: Last Planner System In Construction – Matec Web Of Conference. 117, 00032 (2017) Journal 4: Improving Project Performance Using Lean Construction In Egypt: A Proposed Framework - The American University In Cairo (2013) Journal 5: Critical Success Factors For Planning, Scheduling And Control In Design And Construction – June 2015 Journal 6: Comparative Study Of Last Planner System Over Traditional Construction Processes Journal 7: Last Planner®: 5 + 1 Crucial & Collaborative Conversations For Predictable Design & Construction Delivery (Dec 2015) Journal 8: Lean Project Delivery — Innovation In Integrated Design & Delivery – Research Gate , Year – 2014
Literature Case Study: 01 - 04	01- Housing Units In Damaturu, Nigeria 02- Four Floor University Underground Garage, US 03- Federal University, North Central Region, Nigeria 04- Comparative Analysis Of Restrictions Faced During Lean Implementation
Live Case Study 1 (Literature)	SS Logistics, Iggalur, Bangalore
Live Case Study 2	Schwing Stetter (Global Concrete Pump Manufacturing Facility), Cheyyar, Tamilnadu – Building 03 (Civil Core – Substructure)

Table 1.2 Literature – Special Study Content

LITERATURE - SPECIAL STUDY	
TYPOLOGY	TITLE
SPECIAL STUDY	• Last Planner System • Choosing By Advantages (CBA) • Co-Location / Big Room (Online / Offline) • Continuous Flow • Increased Visualization • Daily Huddle Meeting • First Run Studies • A3 Design Thinking / Problem Solver

Table 1.3 Literature & Live Case Study Content Purpose

LITERATURE & LIVE CASE STUDY	
TYPOLGY	PURPOSE
Research Paper	• Awareness of Lean & LPS • Current Challenges faced by Construction Industry due to Convention Construction PM System and Expected / Required Solution • Method of Implementation of LPS • Benefits of LPS
Literature Case Study: 01 - 04	• Method of Implementation of LPS • Restrictions faced during Implementation of LPS • Motivation & Methods used to overcome those restrictions faced during implementation of LPS • Benefits of Implementing LPS • Work Methodology & Different Meetings & Reporting Systems of LPS
Live Case Study 1 (Literature)	• Method of LPS Implementation • Example of LPS for Footing Work • Organisation Chart • LPS Formats/ Templates • Work Methodology & Different Meetings & Reporting Systems of LPS used here
Live Case Study	• Analyse Conventional PM System Implemented during Construction Stage – Substructure Civil Work • Analysis Delay Reason, their Challenges faced during Implementing Conventional PM System for Construction Stage – Substructure Civil Work • Comparison Project Management Process for Construction Stage – Substructure Civil Work for Conventional PM System Implemented here Vs. Standard Conventional PM System (To Understand the deviations) and Lean Last Planner System to be Implemented • Lean Waste Classification • Overall Challenges, Aspirations & Solution as LPS • Method of Implementing LPS & Templates

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter identifies the present state of affairs whereas implementing standard Project Management System and Lean Awareness, the prevailing essential success factors, Restrictions faced and Motivations for lean coming up with implementation throughout construction part and also the procedure for Implementing Last Planner System as a Lean Construction coming up with Tool.

2.2 DEFINITION OF CONSTRUCTION PROJECT PLANNING

1. Construction coming up with may be a basic and difficult activity within the management and execution of construction comes.
2. It involves the selection of technology, the definition of labour tasks, the estimation of the specified resources and durations for individual tasks, and also the identification of any interactions among the various work tasks.
3. A decent construction set up is that the basis for developing the budget and also the schedule for work.

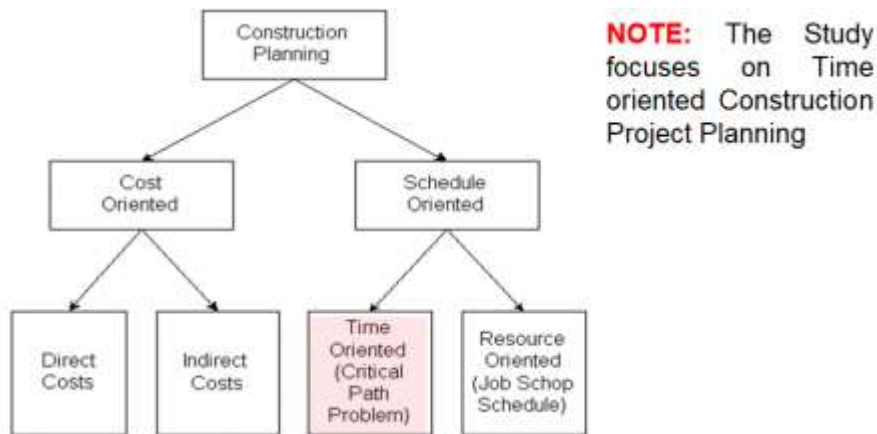


Fig 2.1 Construction Planning Process

2.2.1 Steps for Construction Project Planning

- Step 1: outline the scope of labour, methodology statement, and sequence of labour.
- Step 2: Generate the work breakdown structure (WBS).
- Step 3: Develop the organization breakdown structure (OBS) and link it with work breakdown structure.
- Step 4: confirm the link between activities – CPM (Critical Path Method).
- Step 5: Estimate activities time length, price expenditure, and resource demand.
- Step 6: Develop the project network.

2.3 LEAN CONSTRUCTION PLANNING

Lean construction (LC) may be a methodology of production aimed toward reducing time, materials, price and energy. The methodology stress on removal of waste or minimize the non-value additional activity and maximize the worth additional activity, maximize the worth and output, generate continuous uninterrupted flow of a project whereas minimizing wasteful aspects and time delay.

It identifies 3 forms of waste; Muda, Mura, And Muri, conjointly called the 3Ms.

Muda: Muda is concerning obtaining eliminates waste, associated refers to an activity or method that doesn't add price

Mura: Mura is concerning eliminating variances within the advancement method at a planning and operation level so everything flows equally.

Muri: Muri is concerning removing overload so the nothing slows down.

2.3.1 Principle of Lean Planning

- Specify the worth desired by client
- Remove gratuitous steps, determine steps through price stream.
- Continuous flow method of added steps
- It empowers answerableness
- Introduces pull coming up with between every step wherever continuous flow is feasible.

2.3.2 Lean Focuses On

- Generates price as client's objective: Eliminate process, minimize waste and optimise as an entire. Increase productivity & safety.
- Focus on flow: Organise production as continuous flow
- Respect for individuals and human central approach
- Continuous Improvement
- Reduce Time, Cost, Time and energy
- Pull planning, simply in time

2.3.3 Benefits

- Construction time will greatly be reduced by inflated coming up with and strategic vision.
- Fewer accidents and the next rate of safety through inflated employee focus and understanding.
- Increased schedule reliability and foregone conclusion.
- Improved overall results because of inflated communication and fewer staff.
- Decreased stress for staff and management because of fewer staff.
- Increased productivity all around because of the next rate of designing.
- Increased profits and turnovers, with inflated client satisfaction.
- Increased employee answerableness.
- Increased job satisfaction leading to additional performance commitment
- Learning from each other facilitated United States of America help one another
- Openly mentioned and resolved problems
- Accuracy of model allowed for batching & manufacture
- Coordination complete before construction, which implies no overtime required to form coordination drawings.

2.3.2 Tool / Technique Lean Construction Planning - Time Management

- Scheduling, Monitoring, dominant & trailing Tool - Last Planner System (LPS), Huddle meeting, visual image, FRS

2.4 RESEARCH PAPERS

2.4.1 Research Paper 01: Lean Project Delivery — Innovation in Integrated Design & Delivery – Research Gate, Year - 2014

Author: Alan Mossman, Senator Ballard & Christine Pasquire

Purpose of the Journal: however lean is effective for project management & method for project delivery than standard project management system

Findings: From survey – old Construction Stakeholders (Lean Practitioners & Non-Practitioners)

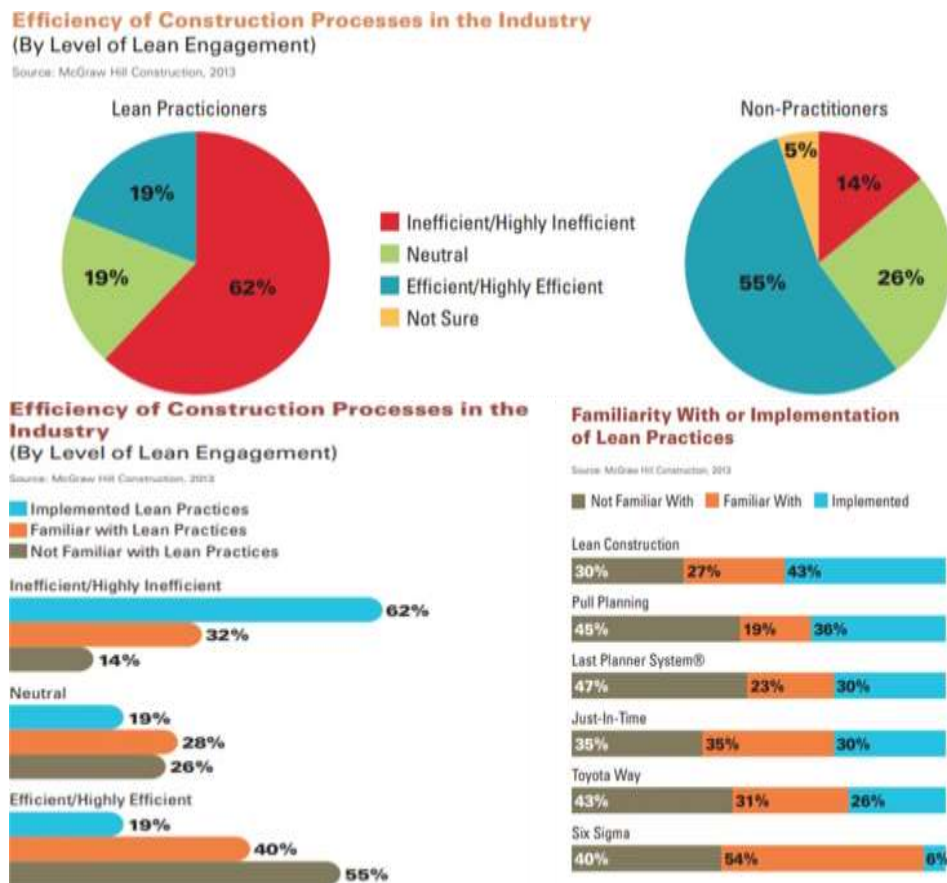


Fig 2.2 Efficiency of CPM & Familiarity of Lean Techniques

2.4.2 Research Paper 02: Traditional Project Management Approach, Industry Challenges And Key Attributes: A Case Study of Construction Project Management in Sri Lanka – Asian Pacific Journal of Advanced Business & Social Studies

Ancient Project Management Approach, trade Challenges And Key Attributes: A Case Study of Construction Project Management in Democratic Socialist Republic of Sri Lanka – Asian Pacific Journal of Advanced Business & Social Studies – Year 2019

Author: Himali Ekanayake , Raduwan Bin Idar , Fadhil

Purpose of the Journal: This paper tries to analyse the challenges through survey (PMC & alternative Construction Stakeholders) in terms of key attributes of the standard project management approach in construction project management and also the expected attributes of future project management methodology

Findings - Expected New Concepts:

New project coming up with ideas acted joined of the bases for explanation the framework of hybrid ideas standard & Lean primarily based PM System, projected that effective communication among all the parties, correct coordination, collaboration, versatile Integrated style delivery and correct amendment order management, clear objectives and deliverables, waste diminution, root cause downside finding methodology and continuous learning from expertise for perfection area unit the foremost necessary factors for a positive improvement of project performance.

2.4.3 Research Paper 03: Last planner system in construction – MATEC Web of Conference. 117, 00032 (2017)

Author: Katorzyna Cwik, Jerzy roslan

Purpose of the Journal: Comparison between Last Planner System and standard Project coming up with System

Findings: 66% to 70% - Delayed in UK using CPM FROM 2012 to 2013

Last Planner System - LPS is that the cooperative, Commitment primarily based coming up with system that integrates “Should-Can-Will-Did” coming up with: Pull Planning, preparation Look-Ahead coming up with Constraint Analysis, Weekly Work coming up with primarily based Upon PPC (Percentage Project Complete).



Fig 2.3 CPM Vs. LPS

Table 2.1 CPM Vs. LPS

Critical Path Method	Last Planner System
CPM logic embedded in software	Applied common sense
High maintenance	Low maintenance
Managing Critical Path	Managing variability
Focus on managing work dates	Focus on managing work flow
Planning based on contracts	Planning based on interdependencies

CPM logic is embedded in code and focuses on managing dates and also the coming up with isn't valid and helpful any longer. Whereas LPS applies the wisdom in coming up with and focuses on the graceful work flow similarly as takes under consideration the interdependencies between activities and section pull coming up with system.

2.4.4 Research Paper 04: Improving Project Performance Using Lean Construction in Egypt: A Proposed Framework - The American University in Cairo (2013)

Author: Marwa Gamal Swefie

Purpose of the Journal: advantages of Lean Construction coming up with throughout construction stage

Findings:

Time & price reduction by implementing lean tools for project coming up with & execution throughout construction stage

Lean Techniques & their implementation result:

- For coming up with, monitoring, dominant & tracking- LPS, Huddle Meeting, mental image, FRS – Time Reduction & Productivity and transparency improved.
- For Execution- VSM (Value Stream Mapping); 5 S's System & Fail safe for quality - price & Material Reduction

Results:

- In African country to some Lean Construction Techniques in construction of eighty housing units. These techniques embody Last Planner, Daily Huddle conferences and Increase visual image. Has resulted effective time management, complete project in sixty two days that lead to a ton of savings in the project price. The productivity has inflated by forty third. Additionally it improved transparency.
- Another study shows VSM will improve the performance website management to check the flows of materials, resources and data and price is reduced by eightieth.
- When utilized all the lean tools on a parking garage project the project has completed below budget and three weeks ahead of schedule.

2.4.5 Research Paper 05: Critical Success Factors for Planning, Scheduling and Control in Design and Construction – June 2015

Author: Elías Bjarnason

Purpose of the Journal: Project Time Management, SWOT Analysis of standard & Lean construction project coming up with system

Findings: Lean approach was a lot of winning in reference to meeting the objectives for coming up with, planning and management and is also effective in dealing and reducing uncertainties.

Project Time Management ensures timely completion of the project. Its main focus of Project time management includes:

- Develop Schedule is that the method of analysing activity sequences, durations, resource needs, and schedule constraints to make the project schedule.
- Control Schedule is that the method of watching the standing of the project to update project progress and managing changes to the schedule baseline.

Failure reason for standard project planning- construction stage:

- The final objective is unaware or not focused by everybody.
- The staffing needs weren't a priority. Nobody is aware of the staffing needs.
- Corporate goals aren't understood at the lower structure levels
- Plans comprehend an excessive amount of in insufficient time.
- Financial estimates area unit poor.
- Plans area unit supported lean information.
- No try is being created to order the look method.
- No one is aware of the main milestone dates.
- Project estimates area unit best guesses, and aren't supported standards or history.
- Not enough time has been given for correct estimating.
- No one has daunted to visualize if there'll be personnel obtainable with the required skills.
- People aren't operating toward equivalent specifications.
- People area unit systematically shuffled in and out of the project with very little regard for schedule.

2.4.6 Research Paper 06: Comparative Study of Last Planner System Over Traditional Construction Processes

Author: Amit Shankar Munje; Dhananjay Subhashrao Patil

Publication: Current Trends in Technology and Science - ISSN: 2279- 0535. Volume: 3, Issue: four (June-July 2014)

Purpose of the Journal: Comparison between LPS & standard coming up with System

Findings: The last planner system, applied will improve ancient methodology and implying a culture of continuous improvement and reducing time and price at the same time.

Traditional Construction Management:

- Concentrates on: what they “should” do. Project management thenceforth monitors and enforce correspondence of “did” to “should”.
- Project manager at the execution stage is replaced by controller.
- When one person causes delay in completion of his work, it delays the whole chain of labor within the project.
- When provider doesn’t come on time it will cause delay in activity because of late delivery of fabric at website.

Last Planner System (LPS):

Last Planner System (LPS):

It emphasizes on collaboration / team work and commitment based mostly approach.

The Last Planner is that the person/team assign for operational coming up with, that facilitate to improved sequence of labour, completion of individual appointed task at the operational level.

In the last planner system, the sequences of labour include:

- Master schedule,
- Reverse section schedules,
- Six-week look ahead,
- Weekly work arrange,
- Percentage complete,
- Constraint analysis and Variances analysis

Provides optimized schedule coming up with through a pull technique, sequence that matches work flow and capability for corporal punishment work.

- “Should” indicates the work needed to be done consistent with planned schedule demand.
- “Can” indicates the work with will really be accomplished on account of assorted constraints on the sphere.
- “Will” reflects the work commitment.

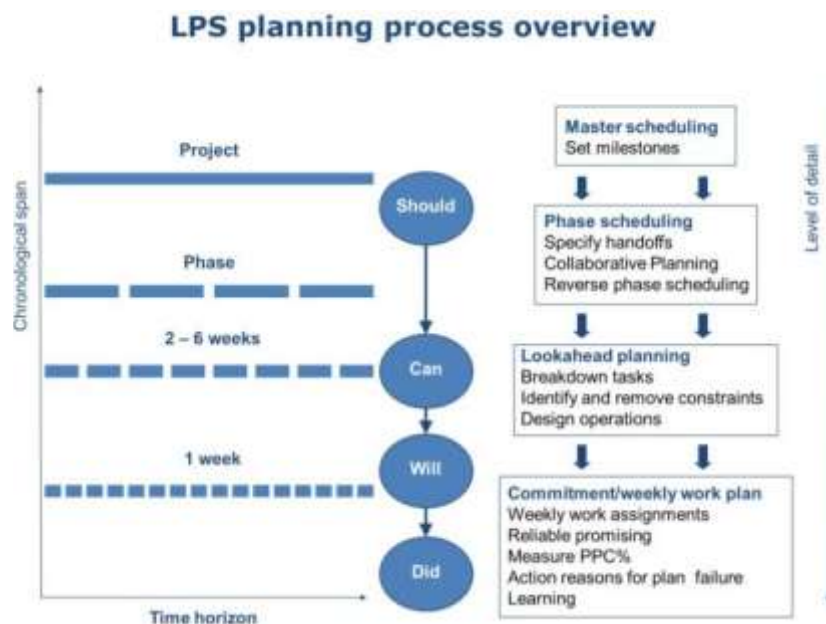


Fig 2.4 LPS Overview

Sequence of Last Planner System:

1. Master Plan:

This is to get a general arrange and determine all the work packages for the total project showing the most activities, their length, and sequence.

2. Reverse Planning:

It is regarding dividing into numerous phases elaborated work plan and supply aims which will be thought of targets by the project team. section coming up with may be a gap between the program and appearance ahead coming up with.

3. Look Ahead coming up with (6 or two Weeks Look Ahead)

In the look ahead coming up with management focusing and provides attention on what's presupposed to happen at it slow in the longer term, and to require actions within the gift that cause that future work.

4. Weekly Work arrange

This is the arrange taken from the contractor tasks for future day or week via weekly conferences, done by conducting weekly meeting.

The weekly work arrange meeting covers the weekly plans, safety issue, quality issue, resources, construction ways, and any issues that occur within the field.

5. Percentage Completed (PPC) & Analysis Of Reasons For Non-Completed Tasks:

In this up the project coming up with by continual analysis and learning from stoppage. PPC is determinant of the proportion of guarantees created that are delivered on time.

Benefits of last planner system:

- Smooth work flow.
- Expected work plans.
- Reduced price.
- Reduced time of project.
- Improved productivity.
- Greater collaboration with field personnel and sub-contractors
- Personal commitment of last call manufacturers (last planners).
- Coordination of the last planners through regular conferences.
- Use of a basic indicator known as planned tasks completed as planned (PPC).

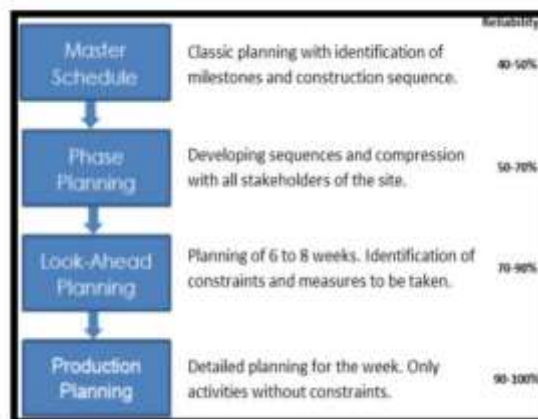


Fig 2.5 LPS Stages Schedule Reliability

Table 2.2 CPM Vs. LPS

SL. NO.	TRADITIONAL PROJECT MANAGEMENT SYSTEM	LAST PLANNER SYSTEM
1	The errors between the dependencies of the activities are not considered.	Primarily the errors are taken into account before making the dependencies between the activities.
2	It focus is on increasing the productivity of each activity which results in errors and reduced quality of work resulting in reworks.	In this, main focus is on the proper flow of activities as per dependencies which results in reduced errors and reworks.
3	This method at times does not consider the customer's requirements which results in reduced customer satisfaction.	Due to the consideration of customer's requirement and proper planning, there is surety of customer satisfaction.
4	In the traditional method, customer is not involved in planning stage.	End user/ customer are involved in start to end planning and design.
5	Traditional method relies on variance detection after the completion of tasks.	In lean construction, controlling is practiced during the task performance.
6	Here push techniques manages the release of information and materials.	In the lean approach, pull techniques govern the flow of information and materials.
7	It not tries to mitigate variation in (product quality, rate of work).	It tries to mitigate variation in every aspect (product quality, rate of work) and manage the remaining variation
8	It does not pay attention to continuous improvement.	Make continuous improvements in the process, sequential workflows
9	In Traditional construction management, decision making is centred to one manager some times.	In lean construction, decision making is distributed in all those who are involved.
10	Does not consider transparency	Increase transparency between the customer, managers and labours
11	Persists on optimizing each activity	Here the system optimises project as a whole.
12	Manages a project at the macro level.	Manages both macro & micro level

Table 2.2 Problems in Traditional Construction Management and Solution by Lean Construction Management

Sl. No.	INFLUENCING FACTOR	TYPE OF WASTE	OVERALL LEAN SOLUTION
1	a) Transportation of material and equipment. b) Worker waiting for material. c) Design changes.	1. Delay in time 2. Rework & Material wastage.	1. Creating Standard procedures to be followed by workers 2. Continuous Collaborative team work 3. Value generation to the customer is done at different stages
2	a) Unsynchronized processes. b) Excessive wasteful activities (like material shifting, late start of work). c) No standard procedure/method. d) Gap between planned work & actual achieved.	1. Delay in time 2. Material wastage Cost increase.	4. Flexible approach of planning system using LPS 5. Pull and continuous flow principles of lean
3	a) A supplier does not supply the material on time. b) Variation in labour efficiency. c) Delay in payment of contractor.	1. Delay in time 2. Low productivity	6. Transparency in all activity 7. Continuous Learning/Improvement
4	a) A supplier does not supply the material on time. b) Material mismanagement c) Rework due to design changes d) Poor quality.	1. Delay in Time 2. Wastage of Material due to rework.	8. Root cause problem solving 9. Performance based incentive scheme
5	a) Unfilled commitment.	1. Delay in Time. 2. Increased costs.	10. Commitment based approach-PPC
6	a) Gap between planned work & actual achieved b) Assignment of inappropriate manpower. c) Proper manpower not assign by contractor for particular activity	1. Delay in Time. 2. Wastage of Material.	
7	a) Late arrival and early departure to/from construction area	1. Delay Time waste	

2.4.7 Research Paper 07: Last Planner®: 5 + 1 crucial & collaborative conversations for predictable design & construction delivery (Dec 2015)

Author: Alan Mossman

Publication: analysis Gate- 235791767 (December 2015)

Purpose of the Journal: Understanding on Lean project – LPS

Findings: The LPS improves sure thing & reliability of construction production & complete project quicker than typical system

Applicability of LPS: The LPS works on tiny & massive Scale comes

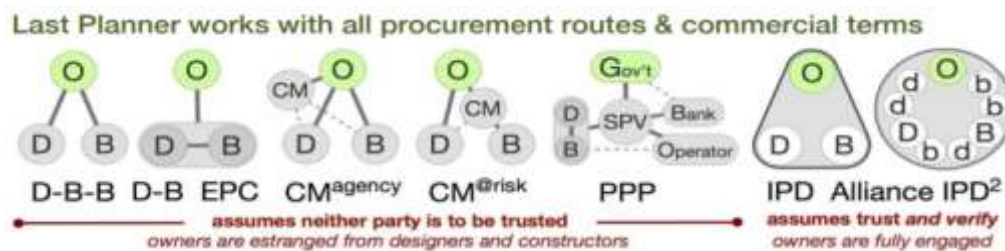


Fig 2.6 LPS Applicability- Project Model

The new strategy Developed by lean:

- Aligns individuals, systems, business processes & practices to
- Harness the skills & insights of all participants in order that they'll
- Create the specified price for the client (while making associate degree applicable come for all stakeholders),
- Reduce waste & maximise effectiveness throughout all phases of style, fabrication & construction.



Fig 2.7 The Eight Construction Requirement

Critical Path technique (CPM) can't be used as a managing tool for a program:

As per senior managers in a very massive international construction corporations delineated it as a list won't to check the practicability of finishing a program in a very given time-frame, its utility stops there and CPM isn't economical to manage a program.

There are several reasons why organizations and comes adopt last planner:

- To determine & address potential issues before they become obstacles within the project

- To facilitate improve the production method reliability
- To scale back the incidence of unhealthy news & to urge what unhealthy news there's early
- To produce those are a reliable client for just-in-time deliveries
- To develop superior skills and scale back the load on management
- To mobilise social pressure through commitment management
- To produce a lot of foreseeable & reliable production program
- To deliver with a lot of safely, quicker & at reduced price
- To stabilise comes and support alternative lean actions
- To deliver comes with bigger price sure thing
- To improve construction supplying on comes
- To improve predictions of labour needed
- To scale back the danger of harmful loss
- To complete comes on schedule

5 + one Crucial Conversations - Building Trust among Key Performers

- Collaborative Programming —creating and agreeing the assembly sequence (and press it if required)
-
- Make ready— creating tasks within the Look Ahead amount prepared (i.e. constraint free) so they will be done once the team need to try and do them.
-
- Production planning— collaboratively agreeing production tasks for future amount (shift, day or week)
-
- Production Management — collaboratively observance production to stay activities not off course
-
- Measurement, learning and continual improvement — learning along regarding and up project, coming up with and production processes.
-
- The further system includes 1st Run Studies (FRS).



Fig 2.8 LPS Level of Detailing

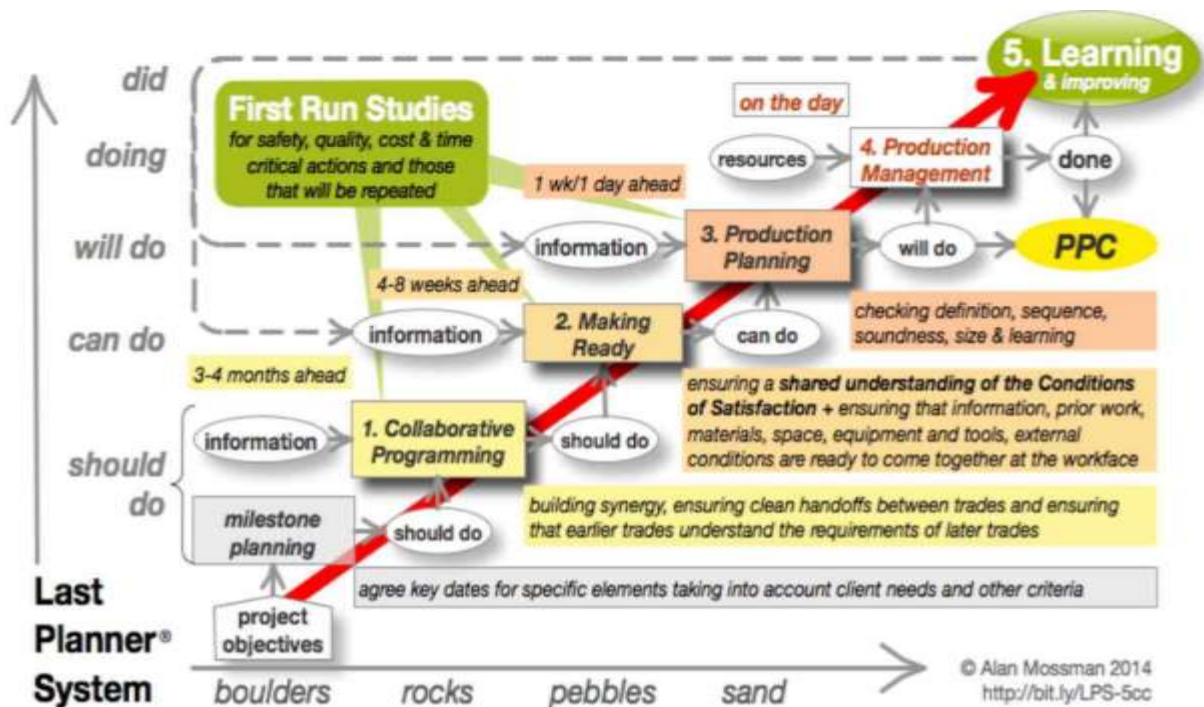


Fig 2.8 LPS Process Overview

5 + one Crucial Conversations - Building Trust among Key Performers

- Collaborative Programming —creating and agreeing the assembly sequence (and press it if required)
-
- Make ready— creating tasks within the Look Ahead amount prepared (i.e. constraint free) so they will be done once the team need to try and do them.
-
- Production planning— collaboratively agreeing production tasks for future amount (shift, day or week)
-
- Production Management — collaboratively observance production to stay activities not off course
-
- Measurement, learning and continual improvement — learning along regarding and up project, coming up with and production processes.
-
- The further system includes 1st Run Studies (FRS).

	Plan level	Responsible	Where	Time scheduling
	Project design & development	Project Manager Design Manager	Pre-project/ initiation stage	Develop collaborative program for design Establish decision schedule
1	Master schedule	Project manager	<i>Before project start on site</i>	Develop overview of main activities; Set milestones
2	Collaborative program; phase program	Site manager	Collaborative programming meeting	Develop phase program
3	Make Ready 5-9 weeks	Site manager	Make Ready meeting	Detail activities; Identify & remove hazards
4	Production Plan 2-4 weeks	Foreman	Production Planning meeting	Ensure all activities have similar level of detail & follow correct sequence; Identify & remove hazards
5	Team plan coming week	Team supervisor	Team meeting	Go through activities for the coming week
6	Production Management daily	Individually, and team based	Morning meeting	Decide final team plan; review incidents from yesterday; go through today's operations

Fig 2.9 Overview of 5 + 1 Crucial Conversations in Last Planner System

2.4.8 Research Paper 08: Lean Project Delivery — Innovation In Integrated Design & Delivery – Research Gate , Year – 2014

Author: Alan Mossman, John Herschel Glenn Jr. Ballard & Christine Pasquire

Purpose of the Journal: to work out however enabling of integrated style and delivery of comes victimization Lean project delivery principles & tools is effective for project delivery as compared to ancient / typical system of project management

Method: Description and analysis of action analysis & learning in current apply

Tools: Incorporated as a lean tool: A3 style thinking, Evidence-based style, Set-based style, Target price style, Integrated Project Delivery, Last Planner System, Collaboration of Stakeholders

Findings: within the context of Lean Project Delivery with Last Planner System project was able to complete ten months earlier & with Target price style (TVD) comes are completed below market value—so much the maximum amount as nineteen below and expected cost falls as style and construction progresses

2.5 SPECIAL STUDY

2.5.1 Choosing By Advantages (CBA)

A methodology of deciding methodology supported the importance of benefits.

2.5.2 Co- Location / Big Room (Online / Offline)

Technique of Lean & IPD (Integrated Project Delivery), that is meant to boost collaboration through bigger team integration by physically conveyance along designers, builders, users and owner along to figure during a single location, usually on-the-scene or inside shut proximity of the project website.

2.5.3 Continuous Flow

Uninterrupted & standardised info flow: RFIs, Submittals, amendment Requests, Project Reports.

- Clear demand & Scope Analysis – All stakeholders
- Clear identification & directions on deliverables & work flow pattern.
- Change order management with a lot of client involvement and proactive action to satisfy the customer's demand.
- Involvement of shopper & user effectively & advisedly is necessary
- Effective engagement of all stakeholders in cooperative approach from starting
- Avoidance of delay of response / info flow; and resulting in price generation by removing waste.

2.5.4 Increased Visualization

It is an info communication key to the personnel through signs and labels associated with safety, schedule and quality- it helps to recollect components like personnel, progress, performance target and specific needed actions.

2.5.5 Daily Huddle Meeting

Daily start-up Meeting for standing update it additionally involves downside finding and a few coaching.

2.5.6 First Run Studies:

It involves PDCA (Plan- Do- Check- Act) approach for continuous improvement, learn and solve downside from its root cause.

2.5.7 A3 Design Thinking/ Problem Solver:

There are varieties of uses of A3s:

- Problem finding – Through PDCA & Root cause Analysis
- Tracking & observance
- Making proposals
- Status coverage
- Strategic coming up with
- Documenting choices

Purpose:

Group of individuals to agree on a haul definition, study the matter and its causes, agree on one or a lot of countermeasures, implement it/them, & live from what happened and what they learnt within the method.

PDCA has five steps look–ask–model– discuss–act (LAMDA for short):

- Look = 'go and see' the matter for yourself,
- Ask others for his or her opinions regarding the problem;
- establish root causes and
- Model the matter victimization the info you have;
- Discuss what you have got learnt with key stakeholders and
- Get agreement so you'll be able to take action.

Design thinking: A non-linear process

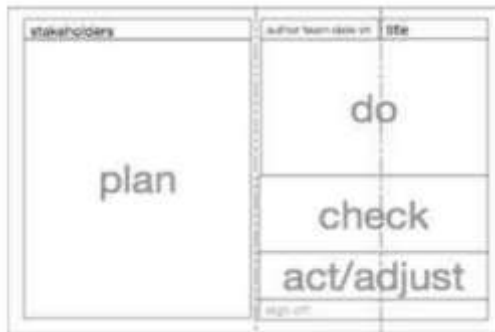
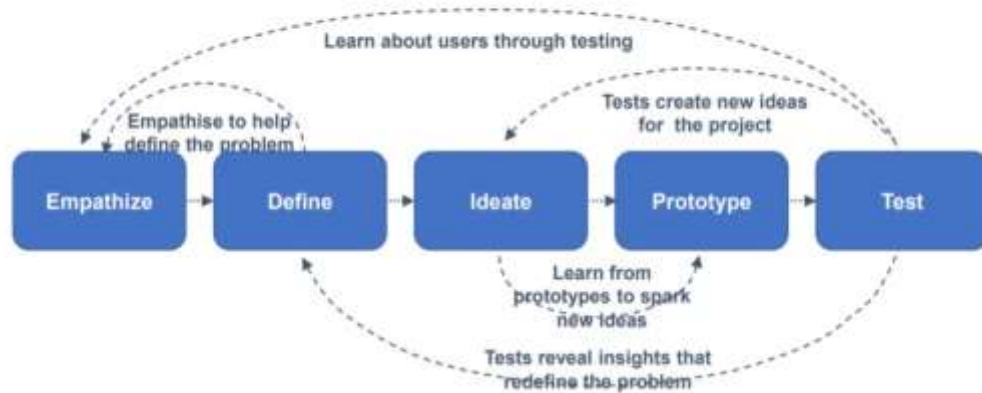


Fig 2.10 A3 Design Thinking – PDCA Approach

2.6 LITERATURE CASE STUDY

2.6.1 Case Study 01 - Housing Units in Damaturu, Nigeria

Low value homes reasonable for LIG by Yobe authorities Of African country.

Managed by Ministry of housing to make three hundred units at state capital:

- A pair of 100 Units – 2 bedchamber Bungalow: Duplex & Semi Detached
- 100 Units – three bedchamber cottage

Ministry of housing has six appointed teams:

- 1 Team – enforced Lean system: Last Planner System by Project Manager on coming up with & operational management
- 5 groups – enforced typical system

Overall Responsibilities of team:

Production, Material Management & Schedule

Master Schedule worn out totally different stages:

Main Structure; Roofing; Finishes; Services

Table 2.3 Project Schedule & Labour Overview

Housing Units	50 / team	50 / team
Team	1 team	5 team
Schedule Implemented	LPS	Conventional
Working day / week	5 Days/ Week	5 Days/ Week
Estimated Completion – Master Schedule	120 Days	120 Days
Estimated Completion – RPS	90 Days	90 Days
Labour Employed/ Unit	7 to 10 per unit	15 per unit
Actual Completion Period	65 to 72 days	More than 120 days
Other Results	Objectives Achieved	Many block (250 Nos.) incomplete after 120 days, completed later by LPS Team

Objectives:

- Waste & non-value added activities eliminated
- Functional 2 way communication provided
- Collaborative Planning

Before Project Implementation – Pilot Project was implemented:

- Study on LPS
- Method of Implementation on LPS
- Training on LPS

Table 2.4 Project Parameters

Parameters	LPS	Conventional System
Minutes of Meeting	Yes	No
Schedule	Yes	Yes
Activity & its duration	Yes	Yes
Completion Date as per Schedule	Yes	Yes
Date Completed	Yes	Yes
Constraints	Yes	No
Reasons for Failure to complete project as planned	Yes	No
Labour Employed to each activity	Yes	Yes
PPC	Yes	No
Interview of Team Members	Yes	Yes

Constraints Faced During LPS Implementation:

- Team members were not familiar with LPS
- Therefore it was tedious job for PM to monitor all the activities
- Team member become fed up with new techniques during the project, but appreciated at the end
- Initially project manager has to maintain all documentation of result, including the subcontractor's work as they do not appreciated the tedious planning work & recordings
- The team members expected that additional management tools are not important to the project objectives, as it make their work more tedious

Method Used To Overcome The Above Constraints:

- The PM proposed an incentive to be given to the committed staff
- This improves the participation of project team to record keeping
- Daily meetings, interviews were conducted on courses of failure to meet up with schedule
- Little constraints were compiled & variance were identified & addressed

Project Performance:

- Completed 18 to 25 days before RPS & earlier than master schedule by 48 to 55 days.
- PPC Value above 70% as no force majeure interrupted the schedule
- Project Participants involvement improved by the provision of incentives
- 2 Way Communication
- Understanding, Accountable, Reliable & Predictable team work
- Problem solving in all WWP Meeting before execution
- Training on LPS to team member
- Problem solved by project manager
- Human Errors in small number were also taken care

2.6.2 Case Study 02 - Four Floor University Underground Garage, US

Cast in place reinforced concrete structure, 5 Storey building to built on top of garage of steel frame & reinforced masonry walls for retail shops & dormitories.

Size of garage: 133,500 sq ft

Project Duration:

- Working days / Week= 5 days/ week
- Master Schedule - 105 working days
- RPS – 89 days
- But completed – 81 days

Project Participants:

- General Contractor
- Formwork Subcontractor (Sub A)
- Rebar Subcontractor (Sub B)
- Vice President of GC & A Research Team (RT) – Experienced in LPS & Implemented LPS

Table 2.5 Project Labour Force

PROJECT LABOUR FORCE	
General contractor (GC)	7 staffs & 26 workers / day
Sub A	14 workers / day
Sub B	15 worker / day

Objective behind Implementing LPS Here:

- Waste & non-value intercalary activities eliminated
- Functional a pair of method communication provided
- Collaborative

Before Project Implementation – trial was implemented:

- Study on LPS
- Method of Implementation on LPS
- Training on LPS

Project Team Classification Into two sorts supported Functions Performed:

1. Planner's Team:
 - a. junction rectifier by: Project Manager
 - b. Focus on: Operational coming up with & dominant
 - c. Members:
2. GC's Superintendent
3. Foreman
4. Project Engineer (Incharge of website safety)
5. Sub A
6. Sub B
 - a. they're all known as as last planner
7. Worker's Team:
 - a. junction rectifier by: Carpenter Foreman
 - b. Focus on: Daily Huddle Meeting
 - c. Members:
8. Labours
9. Carpenters

Challenges featured whereas Implementing LPS:

- dynamic Mind-set & Behaviour of team members with lean technique was challenge
- unacquainted with / Misunderstanding of lean ideas & Implementation
 - PM powerfully reacts, puzzled his management ability in question
 - He emphatic that there's no would like for extra management tools
 - Most of the last planners thought that further management tools weren't appropriate for housing industry
 - Last Planners felt it as extra add on & had adscititious an excessive amount of to their work
- Initial concern to questioning the standing of the project & sharing ideas by staff to higher authorities

The on top of Challenges Has Resulted In:

- Initial incomplete implementation of all the tool
- No constraints were indicated
- Low accuracy of constraints & variance were provided
- No daily huddle conferences happened
- RPS was created just for part 1- Underground garage Construction & not part two – on top of structure

Solutions enforced to beat Challenges featured throughout Implementation of Lean Here By, PM & RT:

- GC Offered coaching categories
- Incentives & promotions / recognition:
- Promote behavioural amendment
- Encourage worker involvement
- Rewarded real improvement
- Encouraged open 2 way communication

Challenges featured whereas Implementing LPS:

1. Dynamic Mind-set & Behaviour of team members with lean technique was challenge
2. Unacquainted with / Misunderstanding of lean ideas & Implementation
 - PM powerfully reacts, puzzled his management ability in question
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Results:

- Constraints Analysis (at create prepared Meeting):

- Material, Verify period of activity meets schedule, Labour convenience as per schedule for every activity
- Note: even supposing project anticipated Constraints at early stage, Variables weren't thought of.
- Variable Analysis:
Performance of previous week wasn't reviewed throughout WWP Meeting as issues were half-track on the spot and were solved at spot

Other Major problems featured here by Human Error:

- Unclear Indication of the drawings by creator and engineers:- data; Sections & elaborate drawing for connections; Measurements; little scale drawings & Information
- Due to the current, delay has occurred, labours waited for engineer and principally junction rectifier to remodel

Table 2.6 Task Scheduling Accuracy

TASK SCHEDULING ACCURACY			
	No. of Tasks	Duration	Accuracy Of Schedule
GC	84	1 or 2 day short duration	• 1 day over- or under-estimated • But comparatively more accurate
Sub A	16	5 to 10 days long duration	Marginal
Sub B	32	Mixed duration	2 nd Accurate

Table 2.7 LPS Measures Implemented

Tools		Criteria for Assessment		
Last Planner		Pull Approach, quality, knowledge, communication and relation with other tools		
Visualization		Visualization, continuous improvement, knowledge, communication and relation with other tools		
Daily Huddle Meetings		Time spent under control, review work to be done, issues covered, communication and relation with other tools		
First Run Studies		Action Plan, continuous improvement, knowledge, communication and relation with other tools		
		Average Score		
Tools	Measure Items	Initial	Achieved	Expected /Target
Last Planner	Reverse Phase Scheduling, Six Week Look-ahead, Weekly work Plan, PPC Charts and reasons for variances	3.6	7.2	6.25
Visualization	Commitment Charts, Safety signs, Mobile signs, Project milestones and PPC Charts	3.4	7	6.75
Daily Huddle Meetings	All foreman meeting and start of the day meeting	4.6	7.4	4.75
First Run Studies	Plan, Do, Check, Act and Productivity Studies	3.1	6.6	4.25

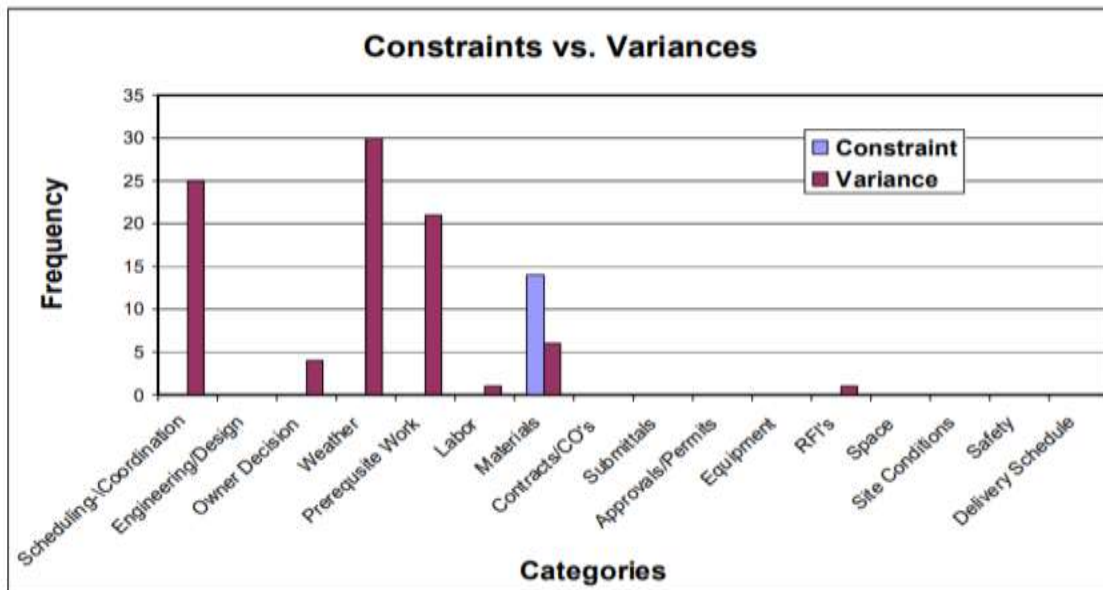


Fig 2.11 Constraints Vs. Variance

FRS (First Run Studies):

- Estimated Productivity before Project start: 53% to 62%
- Initial achieved Productivity: less than 30%
- Due to:
 - Material placing too far
 - Weather Condition
 - Alignment problem from the prerequisite work performed by other trade
- After first Run Study, Productivity Increased: 3 times the previous value and more
- Due to:
 - PDCA Approach- Root Cause Problem Analysis & Continuous improvement
 - Closure Placement of Material
 - Training
- Prerequisite check and Approval
- Open, two way communication and friendly atmosphere
- Accountability avoid blaming
- Idea sharing environment between labours, workers, GC, PM, Subcontractors

PPC (Percentage Project Completion):

Phase 1 Completed:

- 8 days ahead of RPS
- 16 days ahead of Master Schedule
- 90% to 100% of GC & Last Planner Goal achieved

PPC Value:

- Initial 20% value of PPC - 60 % to 70 %
- Next 40% - 70% & 90%
- Next 15% - above 90%

Main Reason for :

PPC Downward Slope:

1. Weather- heavy snow and wind chill
2. Initial Scheduling / Coordination
3. Prerequisite site work

PPC High Value:

1. Training
2. Recognition of team
3. New set of sequence to accelerate & Shape work flow rate and optimize productivity by PM
4. Last Planner Commitment & high reliability
5. Repetitive nature of the project

Increased Visualization:

A. Safety Commitment :

- Placed at trailer where safety training was conducted for new employee
- Safety meeting conducted at Job site held at the beginning of the project for staffs and workers.
- To discuss Importance of safety practice of company and feedback from people on site safety at Jobsite.

B. Safety Sign

Placed at different spots of Phase 1 & 2 at site entry and exit, created by workers.

C. Completion Dates:

- Milestones as per RPS;
- Work Sequence;
- Constraints log;
- Completion date for each floor;
- Expected date of completion as per WWP and
- Drawings with work Sequence for workers Placed on the gang boxes at each floors and retaining wall.

D. PPC Chart

- Based on WWP Actual Schedule and Variance analysis by PM
- For each week, trade and overall project
- Daily Huddle Meetings

2.6.3 Method of Implementation of LPS at Case Study 01 & 02

STEP 01- MASTER SCHEDULE

- Developed by: Project Manager
- Utilizes: Push system Approach and Experience from similar project
- Includes:
 - Overall Schedule
 - All phases
- Further Proceeding:
 - Master Schedule
 - Drawing
 - Work Sequence
 - Early warning chart
 - Construction Methodology

PROJECT 1- To distribute before RPS Meeting to: All Planner & Rebar Suppliers

PROJECT 2-To distribute before RPS Meeting to: To project team members

STEP 2- BEFORE RPS MEETING:

- Lean concept & Last Planner Procedure - were explained to all the Last Planner
- LPS Training Provided to: all team members Project Objective linkage with LPS

STEP 3- RPS MEETING:

- Project 1 Participants: All last Planners
- Project 2 Participants: All last Planners & Rebar suppliers
- To Develop: Network of detailed activities in Reverse sequence from Last Activity and the Last Planner
- Procedure:
 - Material Used: Post-its & Long Sheet
 - a. Planners wrote down activities on post-its (1 activity in 1 post-it), Along with individual duration
 - b. Planners stuck those post-its on long sheet as per time line- in backward sequence from the target completion date.
 - c. All Planners:
 - a. Identify logic between activities
 - b. Refine the sequence if required by moving post-its
 - c. Discuss & Decide: Which activity would be on critical path
 - d. Determine Floats for those activities on critical path & with uncertainties
 - e. A detailed reverse based schedule is prepared with determination of constraints

Note for Step 03: Master Schedule is guide for RPS Production

STEP 04- SIX WEEKS LOOK-AHEAD (SWLA)

Developed By: Project Manager

Distributed To: Weekly Work Program Meeting Members / Last Planners at WWP Meeting

Procedure:

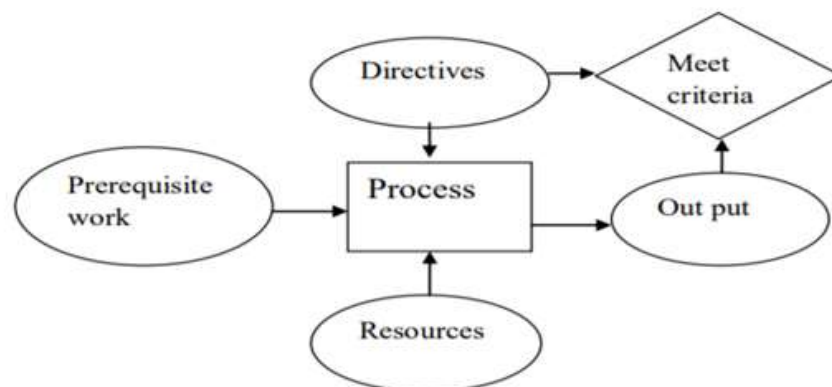
1. It is a 2 weeks or 6 weeks Micro level breakdown schedule with constraints indicated in discussions with other last planners based on RPS & Master Schedule
2. Updated Daily based on progress from actual schedule
3. Research Team (RT) documented constraints with indication by the PM & Performed Constraints Analysis

ADM Model:

Constraints Identification and removal before Activities start, Aids Make Ready Planning to check availability of resources, information and prerequisite for next 2 to 6 weeks, Through Look Ahead window maintaining constraints log.

Primary Category of constraints includes:

1. Directives: Guidance / information to be available for the work to be done or assessed or produced
2. Prerequisite work: Work to be done prior to the activity to take place successfully
3. Resources: Man, Material, Equipment and tools and Money



ACTIVITY DEFINITION MODEL (ADM)

STEP 05- WEEKLY WORK PLAN (WWP)

Project 01 Participants: All Team members, including Honourable Commissioner of Ministry of Housing Held on: Monday every week

Project 02 Participants: All the last planners and Research Team Held on: Thursday every week

Procedure: Each trade submits its own upcoming week's schedule to the Project Manager on the day before WWP Meeting.

Meeting Addresses:

- a. Work to be done for the week; Weekly PPC & Production Plan
- b. Issues of Planning Process such as:
 - Schedule,
 - Manpower,
 - Material,
 - Equipment Availability
 - Safety
 - Construction Methodology,
 - Early warning Charts,
 - Other Problems from job site
- c. First Run Studies - Identify root causes and solving Problem It enhances open 2 way communication

STEP 06- PERCENTAGE PROJECT COMPLETED (PPC)

Prepared by: Project Manager

Distributed To: Last Planners in WWP Meetings

On Basis Of: Week Basis, Trade Basis, Overall Project Basis

Done By:

Comparing every week progress and update on original schedule with actual schedule (Actual Start & Finish) : WWP Schedule and Variance Control table & Analysing them



Fig 2.12 Method of Implementing LPS in Case Study 01 & 02

2.6.4 Case Study 03 - Federal University, North Central Region, Nigeria

Project Background:

- Construct 4 Prototype hostel Building by 4 different contractor.
- First three contractors uses Conventional project planning while the 4th Contractor along with Guidance of project manager continuously implemented Last Planner system.
- Project Cost : 1,200,000

Estimated Project Completion as per Master Schedule:
18 months

Results:

- CRT 1: completed 5 months late
- CRT 2: completed 6 months late
- CRT 3: contractor has abandoned the project due to cost over run
- CRT 4: Started 3 months late but completed 2 months earlier

LPS Implemented here includes:

- Reverse phase scheduling (RPS)
- Look Ahead Planning
- Weekly Work Plan (WWP) & Meeting
- Percentage Plan Completed (PPC) at end of each week

PPC of the Project:

Was low in first week:

- As team members were resistant to LPS Implementation (new system)
- Lack of commitment to change and innovation
- They are sceptical about benefits of LPS Implementation
- Unrealistic Expectations
- Lack of top management commitment

It was overcome by:

- PM interest and training of team members about LPS

Weekly progress of project from PPC improved from 40% to 80% and then to 100% at 16th week due to:

- Project team understood the need to keep promise
- Completing activities as planned
- Improved proactive site planning
- Two way Communication between project stakeholders

Constraints faced here by LPS Includes:

- Material unavailability:
 - Due to increase in Price - Concrete and Steel
 - Distance between Project Site and Nearest supply location for aggregate & other materials were high, leading to shortage of material at site
- Pre-requisite work
- Availability of workforce as project requirement
- Late requests / submittals, incomplete design information
- Defects requiring rework
- Equipment breakdown
- Poor weather

Constraints Addressed by:

By implementing weekly planning & meeting and look ahead/ make ready planning together with regular Constraint analysis to remove the Constraints before they occur.

1. Better Allocation of resources, an organized flow and access of materials, making each team aware of what to do and when to do each assignment through continuous make ready and weekly planning.
2. The problem with material shortage was overcome by 4th contractor by engaging short term and look ahead planning to ensure they are available as prerequisite before work starts.
3. Regular availability of information with the help of make ready and weekly meeting

2.6.5 Case Study 04- Comparative Analysis Of Restrictions Faced During Lean Implementation

Table 2.8 Projects & Typologies

Sl. No.	Project	Typology
1	Advanced Communication and Information Technology Center (ACITC) at Virginia Tech Campus, USA	Institution
2	Four floor University parking garage, USA	Commercial
3	17-storey residential building, Brazil	Residential
4	Construction and refurbishment of an industrial building for a steel & car manufacturer, Brazil	Industry
6	Faculty of Business and Administration building, General classrooms and laboratories, Saudi Arabia	Institution
7	Cathedral Hill Hospital project, USA	Health care

Table 2.9 Challenges Faced while Implementing LPS

Challenges faced by AEC professionals during the implementation and use of LPS	
1	Organizational inertia or resistance to change or "This is how I always done it" attitude
2	Lack of commitment to LPS implementation or attitude towards new systems
3	Lack of human capital - lack of understanding of new system or difficulty to make quality assignments or lack of skills and experience
4	Lack of training
5	Lack of leadership or failure of management commitment or organizational climate
6	Lack of stakeholder support
7	Lack of empowerment of field management or lengthy approval procedure from client and top management
8	Poor use of information generated during implementation of LPS
9	Contracting and legal issues or contractual structure
10	Partial or late implementation of LPS
11	Bad team chemistry or lack of collaboration
12	Bad work ethics and cultural issues
13	Short term vision
14	Inadequate administration
15	Extra resources or more paper work or extra staff or more meetings or Additional time
16	Misinterpretation of PPC indicator

Table 2.10 Motivations for Implementing LPS

Summaries Of Motivations Behind LPS Implementation	
1	Increase work plan reliability
2	Reduce uncertainty
3	Integrating supply chain management functions
4	Improve work flow reliability
5	Improve construction planning practices
6	Shielding production, integration between long- and short term planning, controlling and learning, management of physical flows, cost control and safety planning and control
7	Reducing number of workers
8	Make timely decisions
9	Learning from failures
10	Continuous improvement
11	Reduce cost of construction
12	Eliminate waste
13	Increase profit
14	Reducing batch-size
15	Developing an integrated approach for product and progress design
16	Improving productivity
17	Reducing production time
18	Find relationship between plan reliability and schedule performance index

LPS provides all of the following:

1. A work plan of what should be done
2. An organization chart -who does what?
3. An agreement between trades - when to start and when to finish
4. A logistics plan - when we need materials, trade teams, drawings etc
5. A tool for workflow control - when we want to do which tasks
6. A basis for monitoring progress

Fig 2.13 LPS Output

CRITICAL QUALITY CHARACTERISTICS OF AN ASSIGNMENT:

1. The assignment is well defined.
2. The right sequence of work is selected.
3. The right amount of work is selected.
4. The work selected is practical or sound; i.e., can be done.

Fig 2.14 Characteristics of an Assignment

Table 2.11 Benefits by Implementing LPS

BENEFITS REALIZED BY LPS IMPLEMENTATION	
1	Increased workflow reliability
2	Reduced project delivery time or reduced production time
3	Increased work plan reliability
4	Improved communication among project participants
5	Less firefighting or fewer problems in day-to-day running of project
6	Improvement in quality of work practice
7	Enhancement of managerial practices
8	Knowledge expansion and learning
9	Reduced stress levels
10	Improved work planning ability
11	Improved informational transparency
12	Reduced cost
13	Better resource leveling
14	Better control over assignments
15	Improved safety
16	Improved microlevel planning
17	Improved resource utilization
18	Improved project performance
19	Reduced batch-size

CHAPTER 3

CASE STUDY

3.1 LIVE CASE STUDY 01 - SS LOGISTICS- LIGHT INDUSTRIAL PARK AT IGGALURU, BANGALORE

3.1.1 Project Background

- It is a Light Industrial Park at Iggalur for Flipkart - Warehouse Logistic storage
- Area: 9950.40 Sqm of Shop Floor and 1024Sqm of Mezzanine.
- Other buildings with Warehouse:
- Scrap room, Fire Control room, Transformer with substation, STP with Collection tank, Parking, Fire Fighting, HVAC, Plumbing and other services were included in the project.
- Initial expected project start & end date: 11/12/ 20 to 21/08/21 (249 days)
- Project Start after 1st Delay: 22nd Jan 21
- Estimated Project Completion after 1st Delay: 21 June 21
- Project Management System Followed here- Lean Last Planner System

3.1.2 Project Participants

- SS Logistics – Owner
- Flipkart- Client (3rd Party Leasing)
- Tata Consulting Engineers - Structural Consultant
- EPMCR, Chennai – PMC
- Jyothi Construction - Civil Contractor
- Nikitha- PEB Contractor

3.1.3 Project Organization Chart



Fig 3.1 Organization Chart – Construction Stage

3.1.4 Project Schedule Overview - Footing

- Footing work divided into 3 work fronts based on footing types and similarities to reduce wastage during shuttering and to optimize the productivity of contractor.
- Current Stage: Civil Core- Footing Work 3rd Work front Concerting
- Civil Work – Footing:
 - Footing:
 - Marking For Excavation
 - Excavation & Soil Dressing
 - Soling In Layers
 - Shuttering & Ppc
 - Marking & Rebar Work
 - Footing Shattering & Concrete
 - Deshuttering & Curing
 - Soil Filling In Layers Up To Footing Level

- Pedestal - 1st Lift:
 - 1st lift Rebar Work
 - Shuttering & Concreting
 - Deshuttering & Curing
 - Soil filling in layers up to 1st lift Pedestal
- Grade Beam
 - Excavation/ Soil Filling & Dressing Shuttering & PCC
 - Marking & Rebar Work
 - Shuttering & Concrete
 - Deshuttering & Curing
- Pedestal - 2nd Lift With Anchor Bolt
 - Rebar work
 - Shuttering & Concrete
 - Deshuttering & Curing
 - Soil Filling in layers for PEB Erection

Table 3.1 Footing Progress & Estimated Completion

Footing divided into :	WORK FRONT - 1	WORK FRONT - 2	WORK FRONT - 3	Estimated completion due to delay
No. of Footings	43	37	34	
DURATIONS				
Overall Original	25 Jan 21 – 27 Feb 21	02 Feb 21 – 04 Mar 21	09 Feb 21 – 11 Mar 21	
Estimated completion after delay	10 March 2021	18 March 2021	23 March 2021	
Footing	25 Jan – 08 Feb (12 d)	02 Feb – 13 Feb (11d)	09 Feb – 20 Feb (11d)	11 Mar 2021
Pedestal – 1 st lift	02 Feb – 12 Feb (10d)	09 Feb – 18 Feb (9d)	16 Feb – 25 Feb (9d)	15 Mar 2021
Grade Beam	13 Feb – 24 Feb (10d)	19 Feb – 01 Mar (9d)	26 Feb – 06 Mar (8d)	19 Mar 2021
Pedestal – 2 nd lift	17 Feb – 27 Feb (10d)	23 Feb – 04 Mar (9d)	02 Mar – 11 Mar (9d)	23 Mar 2021

3.1.5 Project Delay Overview - Footing

Reason for 1st Delay of Schedule:

- Excavation started by December 25th to 26th 2020, delayed later due to wrong Geotechnical Investigation done by client employed subcontractor before appointment of Structural Consultant (TCE) and later waited to receive Structural Consultant's (TCE) Guidance on construction methodology to that Soil typology.

Other Overall Delay in Footing Work till today are:

- Rain, Dewatering required
- Labour Availability
- Skilled Labour Availability- Shuttering Carpenter
- Pedestal height was high due to soling which was added , leading to shortage of shuttering material.

3.1.6 Project Meetings

Table 3.2 Project Meetings Held as per LPS

Meeting - LPS	Occurs at	Discussion & reports
RPS Meeting	Project start	RPS from Master Schedule
SWLA Meeting	Month end	Month & 2 weeks Schedule Look ahead window – Prerequisite work, information, resources make ready & constraint log Monthly Report
WWP Meeting	Wednesday	WWP, Daily detailed Schedule, Progress- PPC (Weekly, Trade & Monthly); Risk & Root cause Identification & Action Plan
Daily Meeting	Daily	DPR – Submitted following day – Client & PMC Progress update detailed Reason for delay & Action plan

Table 3.3 Project Meetings Participants

Schedule Based Meetings	Participants
Master Schedule	Client, PMC, Architect, Structural Consultant
RPS Meeting	Client, PMC, Architect, Structural Consultant, Civil Contractor & Land Developer Contractor
SWLA Meeting	Client & Flipkart (If Required) ; PMC, Civil & PEB Contractor, Sub Contractor
WWP Meeting	Client, PMC, Civil & PEB Contractor, Flipkart
Daily Meeting	Daily Progress Report - Client, PMC, Civil & PEB Contractor Daily Huddle Meeting: PMC , Foreman, Labours

3.1.7 Percentage Project Completion

Table 3.4 Civil Work Substructure– Daily Schedule Report Detailed From WWP (For Period : 20 Feb – 28th Feb 2021)

DAY WISE CATCHUP SCHEDULE	Feb-21								
SS LOGISTICS STATUS AS ON	20	21	22	23	24	25	26	27	28
WORKFRONT-01 (A-F)									
Footing Concrete									
Soil Filling in Layers upto FGL in Footings	6	6	6	6	5				
Pedestal -1st Lift in Nos		8	8	2					
Grade Beam in Rmt						60	60	60	20
Pedestal -2nd Lift with Anchor Bolt +Grid Area									11
Soil Filling in Layers for Grid (A-F) for PEB Erection									
WORKFRONT-02(G-Q)									
Excavation & Soil Dressing									
Soling in Layers	3								
Footing PCC		3							
Footing concrete			6	6					
Soil Filling in Layers upto FGL in Footings				6	8	8	6		
Pedestal -1st Lift in Nos				6	8	4			
Grade Beam in Rmt									40
Pedestal -2nd Lift with Anchor Bolt +Grid Area									
Soil Filling in Layers for Grid (A-F) for PEB Erection									
WORKFRONT-03(R- U1)									
Excavation & Soil Dressing		6	6	4					
Soling in Layers		6	6	6	6	5			
Footing PCC		3	6	6	6	6	2		
Footing concrete				6	6	6	6	6	1
Soil Filling in Layers upto FGL in Footings								8	8
Pedestal -1st Lift in Nos						4	8	8	8
Grade Beam in Rmt									
Pedestal -2nd Lift with Anchor Bolt +Grid Area									
Soil Filling in Layers for Grid (A-F) for PEB Erection									

**Table 3.5 Daily Progress Report (For Period : 20 Feb – 28th Feb 2021 / 1 Week) –
Manpower & Progress**

MANPOWER & MACHINERY											
SI.NO.	RESOURCE	PMc RECOMMENDATIONS									
		22-Feb-21	23-Feb-21	24-Feb-21	25-Feb-21	26-Feb-21	27-Feb-21	28-Feb-21	Avg Manpower	Req Manpower	To increase
1	Barbender	5	5	8	8	8	8	8	7	16	9
2	Helper	4	4	5	5	5	5	5	5	12	7
3	Mason	14	14	19	19	15	15	15	16	14	-2
4	M/C	14	14	19	19	17	17	15	16	16	0
5	F/C	15	15	15	15	18	18	8	15	2	-13
6	Carpenter	15	15	15	10	11	11	13	13	20	7
	Total	67	67	81	76	74	74	64	72	80	
1	Excavator	0	1	1	1	1	1	0	1	1	0
2	Tipper	0	2	2	2	2	2	0	1	2	0
3	JCB	4	4	4	4	4	4	4	4	4	0
4	Tractor	3	3	3	3	3	3	0	3	3	0
WEEKLY PROGRESS											
SI.NO.	DESCRIPTION	PROGRESS									
		22-Feb-21	23-Feb-21	24-Feb-21	25-Feb-21	26-Feb-21	27-Feb-21	28-Feb-21	Avg Rate	Req Rate	Cumulative
1	Footing Excavation	3	6	3	0	0	0	0	2	4	110
2	Footing Soling	4	3	3	4	3	2	0	3	6	110
3	Footing PCC	4	2	3	0	6	2	3	3	10	109
4	Footing Concrete	3	8	5	2	3	0	5	4	10	100
5	Footing Back filling	0	0	13	7	9	4	0	5	15	59
6	Ped 1st Lift Concrete	7	5	2	2	9	4	5	5	15	95
7	Grade Beam Concrete	0	0	0	0	0	0	0	0	100	0
8	Ped 2nd Lift Concrete	0	0	0	0	0	0	0	0	11	0
9	PEB Column	0	0	0	0	0	0	0	0	0	0

Table 3.6 Civil Work – Daily Progress Report (For Period : 20 Feb – 28th Feb 2021 / 1 Week) – Backlog

BACKLOG								
Sl.NO.	RESOURCE	22-Feb	23-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
1	Footing Excavation	3	1	4	4	4	4	4
2	Footing Soling	2	4	6	5	6	4	6
3	Footing PCC	2	5	6	9	4	8	7
4	Footing Concrete	3	-1	2	5	8	10	10
5	Footing Back filling	6	10	0	5	7	11	11
6	Ped 1st Lift Concrete	1	4	9	9	4	11	11
7	Grade Beam Concrete	0	0	0	60	80	100	120
8	Ped 2nd Lift Concrete	0	0	0	11	11	11	11
9	PEB Column	0	0	0	0	0	0	0

Reason for delay (22nd to 27th February):

22nd February:

- Shortage of Manpower: Soling, PPC, Concrete, Pedestal 1st lift
- Poor Lighting at Night work: Decreased concrete productivity, safety issues and affects concrete quality
- Rework - Impact of Rain: Excavation & Back filling

23rd February:

- Shortage of Manpower (Soling, PCC, Pedestal 1st lift, Backfilling, Grade Beam Preparation)
- Quality & Safety (Compaction in layer)

24th February

- Shortage of Manpower (Soling, PCC, Pedestal 1st lift, Backfilling, Grade Beam Preparation)
- Quality & Safety (Curing to follow as per Instruction)

25th, 26th, 27th February:

- Shortage of Skilled labour

3.1.8 Recommendation

1. Need to increased Manpower by Civil Contractor
2. Civil Contractor needs to plan parallel activities for Grade beam & Soil filling works to give work front to PEB
3. Civil Contractor needs to arrange proper lighting for night work to increase productivity and safety
4. Civil Contractor needs to follow standards/ drawings- Backfilling & Compaction works in layers
5. Proper distribution of skilled & unskilled labour
6. Curing to be done on regular basis for minimum of 7 days to attain strength of concrete
7. Safety PPE's to be followed for all the labour inside the site premises

3.1.9 Overview of Steps Involved In LPS Implementation

- Identifying Scope, WBS, OBS, Work Methodology, Work Sequence
- Relate WBS & OBS
- Master Schedule Prepared (Macro level) by collecting schedules submitted from other consultants in coordinated manner
- Cycle time for each activity as per labour, equipment & material requirement, workability, process duration and master schedule
- Prepare RPS – Reverse Phase Schedule
- Prepare SWLA – Here Monthly & 2 week schedules are prepared
- WWP – Weekly Plan & Daily detailed Schedule is prepared
- Daily Huddle meeting
- Daily Project Reporting
- PPC
- PDCA

Table 3.7 Six Weeks/ Two Weeks Look Ahead Schedule

		MAY 2020				JUNE 2020			
		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	
CONCRETE WORK	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	
	LOCATION (S) SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	
	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	
	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	
GSB & WMM FILLING WORK	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	ACTIVITY NAME:	
	LOCATION (S) SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	LOCATION SCOPE QTY	
	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	RESOURCES:	
	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	PREDECESSOR ACTIVITY	

CONCRETE WORK	ACTIVITY NAME:
	LOCATION (S) SCOPE QTY
GSB & WMM FILLING WORK	RESOURCES:
	PREDECESSOR ACTIVITY

Table 3.8 Weekly Work Plan / Production Plan

 Proposed Factory building at Thodukadu 								
Look Ahead Schedule (Production Plan) - WEEK 1 For "B" Block								
Location	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Activity
North Grid 1	2700 cft							Excavation
F2- 2No.s, F3 - No.s	Survey and marking							
		73.5 cft						Sand Filling and PCC
		Excavation						

Table 3.9 Weekly Work Plan / Production Plan

SS LOGISTIC	WEEK -01															
TRADE -CIVIL WORK	DAY-01				DAY-02				DAY-03				DAY-04			
APPROVED DRAWING	F	ACTIVITY	Footing Centre Line/	QUANTITY	-				P/AB	ACTIVITY	Pedestal /AB Plan	QUANTITY	-			
	Drawing Check	LOCATION	Entire Building						Drawing Check	LOCATION	Entire Building					
	RESOURCE	Architect,Structural Engineer							RESOURCE	Architect,Structural Engineer						
	DURATION	1 Day	RFI	-					DURATION	1 Day	RFI	-				
SURVEY-Coordinate Marking/RL	F	ACTIVITY	Footing Marking	QUANTITY	6 Nos				F	ACTIVITY	Footing Marking	QUANTITY	6 Nos			
	Drawing Approval	LOCATION	(GRID A-1-2-6)						Drawing Approval	LOCATION	(GRID A1-B2-2 - 2a)					
	RESOURCE	Surveyor,Helper with T.S.							RESOURCE	Surveyor,Helper with T.S.						
	DURATION	1.5 Hr	RFI	1					DURATION	1.5 Hr	RFI	1				

TRADE -CIVIL WORK	DAY-01									
APPROVED DRAWING	F	ACTIVITY	Footing Centre Line/	QUANTITY	-					
	Drawing Check	LOCATION	Entire Building							
	RESOURCE	Architect,Structural Engineer								
	DURATION	1 Day	RFI	-						

Table 3.10 Civil Work – Daily Progress Report- A3 Problem Solver - PDCA

PROJECT: SS LOGISTICS-LIGHT INDUSTRIAL PARK AT IGGALURU				DATE		REPORT NO.	
STAKEHOLDERS:							
BACKGROUND:							
CURRENT CONDITION:							
PROJECT STATUS		PROGRESS ON 22-Feb-21			QUALITY		
DESCRIPTION	Total Com.	Planned	Achieved	Backlog			
		6	3	3			
		0	0	0	SAFETY		
Reason for Backlog:							
TARGET CONDITION/MEASURABLE OBJECTIVE:							
Following activities to be completed on % basis		STATUS ACHIEVED AS PER SCHEDULE					
Example:		DESCRIPTION		Total	Completed	Balance	
100% -Footing		Footing		114	114	0	
(Excavation,Soling,PCC,Concrete)		Pedestal -1st Lift		116	92	24	
ROOT CAUSE & GAP ANALYSIS :							
<pre> graph LR A[Shortage of Manpower] --> B[Soling 4/6 PCC 4/6 Concrete 3/6] B --> C[DELAY IN PLANNED ACTIVITIES] D[Rework- Impact of Rain] --> E[Excavation 3/6 Backfilling 0/6] E --> C F[Poor Light@ Night Work] --> G[Decreases Concrete productivity Affects Quality of Concrete Causes Safety issues] G --> C </pre>							
RECOMMENDATIONS:							
Example: Civil Contractor needs to increase manpower to achieve 6 Nos per day for soil dressing							
IMPLEMENTATION PLAN: As per Weekly wor plan							
COUNTER MEASURES							
TASK		RESPONSIBILITY			DUE DATE		
Add. 1 Team of 10 members for Soling works		Project Manager -Jyothi Construction			Immediate		
2nd Lift Anchor Bolt Check		Project Manager -Nikitha			Start of Grade beam work		
Proper Lighting during night works		Jyothi Construction Team			On Night work basis		
Cube Register		Jyothi Construction Team			On Daily Basis		
PROJECTED RESULTS:							
DESCRIPTION	Current rate /Day	Required rate /Day as per Catchup plan	Req Qty to plan for Next 3 Days	Estimated Duration	Est. Start Date	Est.Com. Date	
Excavation & Soil Dressing	3	6	7	3		25-Feb	
Soling in Layers	4	6	7	4		26-Feb	
Shuttering & PCC	4	6	7	5		27-Feb	

Table 3.11 Civil Work – Week (Working Days) – Manpower, Progress , Backlog & Cause

MANPOWER & MACHINERY									PMC RECOMMENDATIONS			
SI.NO.	RESOURCE	22-Feb-21	23-Feb-21	24-Feb-21	25-Feb-21	26-Feb-21	27-Feb-21	28-Feb-21	Avg Manpower	Req Manpower	To increase	
1	Barbender	5	5	8	8	8	8	8	7	16	9	
2	Helper	4	4	5	5	5	5	5	5	12	7	
3	Mason	14	14	19	19	15	15	15	16	14	-2	
4	M/C	14	14	19	19	17	17	15	16	16	0	
5	F/C	15	15	15	15	18	18	8	15	2	-13	
6	Corepenter	15	15	15	10	11	11	13	13	20	7	
	Total	67	67	81	76	74	74	64	72	80		
1	Excavator	0	1	1	1	1	1	0	1	1	0	
2	Tipper	0	2	2	2	2	2	0	1	2	0	
3	JCB	4	4	4	4	4	4	4	4	4	0	
4	Tractor	3	3	3	3	3	3	0	3	3	0	
PROGRESS									WEEKLY PROGRESS			
SI.NO.	DESCRIPTION	22-Feb-21	23-Feb-21	24-Feb-21	25-Feb-21	26-Feb-21	27-Feb-21	28-Feb-21	Avg Rate	Req Rate	Wk Progress	Cumulative
1	Footing Excavation	3	6	3	0	0	0	0	2	4	12	110
BACKLOG									REASONS FOR DELAY			
SI.NO.	RESOURCE	22-Feb-21	23-Feb-21	24-Feb-21	25-Feb-21	26-Feb-21	27-Feb-21	28-Feb-21				
1	Footing Excavation	3	1	4	4	4	4	4				

Contractor to increase skilled Manpower

Table 3.12 Civil Work – Daily Progress – For each Trade, Work front & PPC

SS LOGISTICS STATUS AS ON	WORKFRONT -01 (43 Nos- GRID A to F)				DELAY ANALYSIS		ESTIMATED COMPLETION -01	
01-Mar-21	PLANNED	ACTUAL	Delay	% PROGRESS	END DATE	NO.OF DAYS	DURATION	END DATE
Footing	43							
Marking for Excavation	43	43		100%				
Excavation & Soil Dressing	43	43		100%				
Soling in Layers	43	43		100%				

Table 3.13 Civil Work – For Overall Project & PPC

SS LOGISTICS STATUS AS ON	OVERALL PROJECT STATUS				OVERALL DELAY ANALYSIS		ESTIMATED TOTAL COMPLETION (HANDOVER TO PEB WORKS)	
12-Mar-21	PLANNED	COMPLETED	INCOMPLETE	% PROGRESS	SCHEDULE END DATE	NO.OF DAYS	DURATION	END DATE
Footing	114							
Marking for Excavation	114	110	4	96%	09-Feb-21	31	1	05-Mar-21
Excavation & Soil Dressing	114	110	4	96%	15-Feb-21	25	1	05-Mar-21
Soling in Layers	114	110	4	96%	16-Feb-21	24	1	05-Mar-21
Shuttering & PCC	114	109	5	96%	17-Feb-21	23	1	05-Mar-21

3.2 LIVE CASE STUDY 02- SCHWING STETTER, CHEYYAR, KANCHIPURAM DISTRICT

3.2.1 Project Details

To build a global concrete pump manufacturing facility at Cheyyar, Kanchipuram district, Since unit at Irungattukottai, Chennai is unable to expand.

PM System Employed here is- Conventional Project Management System during Design & Construction Stage.

Project Location:

SIPCOT Industrial Park, Cheyyar, Kanchipuram District, Tamilnadu



Fig 3.2 Project Location

- **Total Site Area:** 51.77 Acres
- **Major Industrial Building Area:** 56,939 SqM
- **Major Industrial Buildings:**
 - Building 01- PreAssembly & Workshop
 - Building 02- Inspection, Testing & Painting
 - **Building 03 – Concrete Trailer, Boom Assembly & Testing**
 - Building 04 - XCMG Admin
- **Building that is scope of study:** Building 03 – Civil work (Substructure);
Built-up Area: 11,324 SqM (149m * 76 m)



BUILDING -03 Building

Structure:

1. Electronics Room
2. PEB Structure
3. Toilet Building
4. Mezzanine Floor

Why Building 03?

- Less project priority – Project planning, Material management, labour management
- Had most delay duration compared to other blocks but was able to complete prior other projects

Fig 3.3 Project Details

OVERALL PROJECT DURATION:

- Initial Estimated Duration: 01 June 2019 – 31st March 2020
- Actual Duration: 01 June 2019 – 31st March 2021

BUILDING 03 PROJECT DURATION:

- Preliminary Estimated Start Date: 1st June 2019
Note: Initial Delay on Start – Due to Land Approval delay (DC Land).
- Initial Estimated Duration: 20th Sep 2019 – 30th May 2020
Note: Delay due to lack of coordination in drawing for footing alignment.
- Project Actual Duration: 28th Sep 2019 – 15th Jan 2021

CIVILWORK – SUBSTRUCTURE BUILDING 03 DURATION (Delay – 281 days):

- Initial Estimated Duration: 20th Sep 19 -26th Jan 2020 (159 days)
- Actual Duration: 28th Sep 19 – 2nd Nov 2020 (400 days)

Fig 3.4 Project Duration

3.2.2 Architectural Layouts



Fig 3.5 View of Site

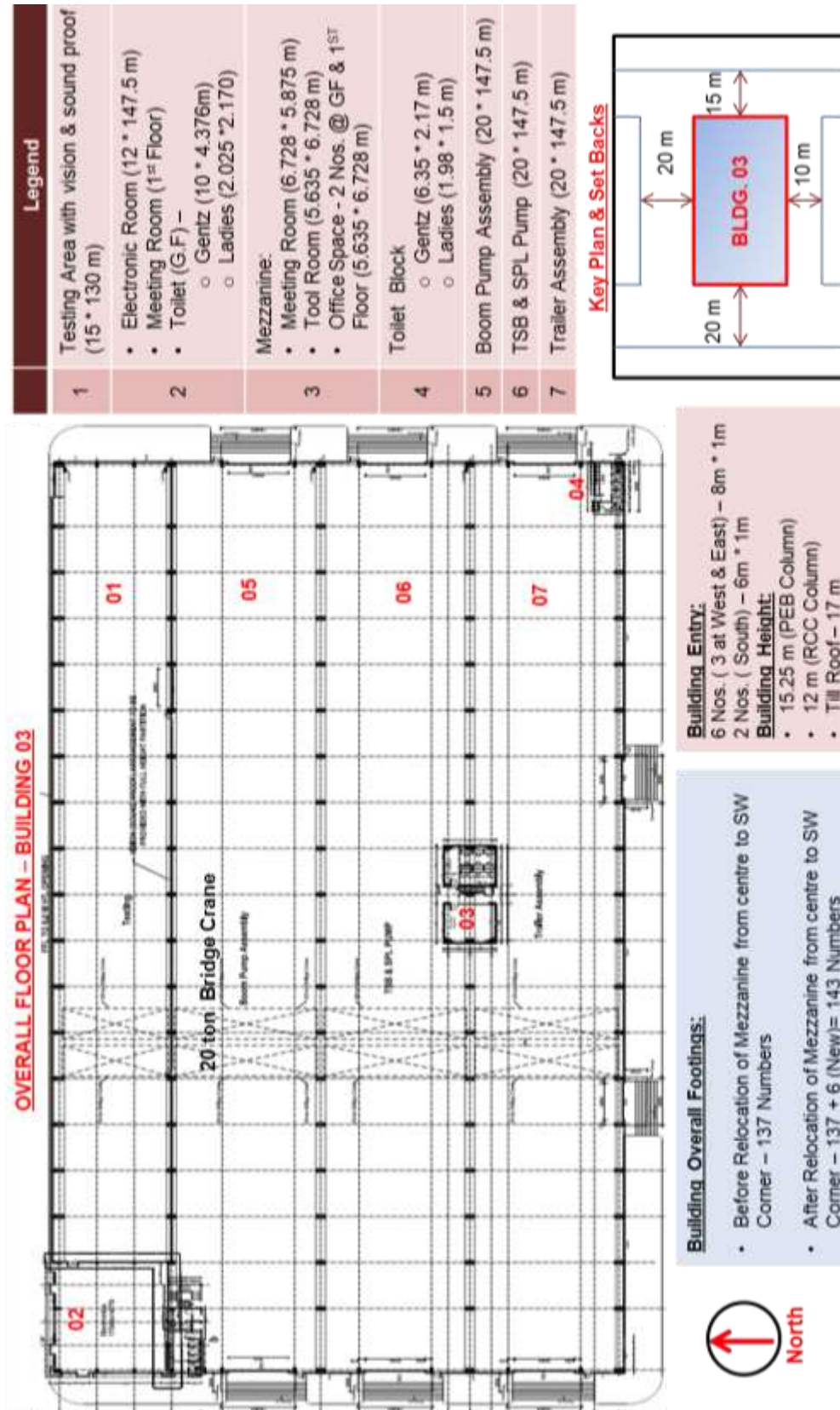


Fig 3.6 Building 03 Floor Plan & Details

[illegible]

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3.2.3 Project Participants

Table 3.14 Project Participants

PROJECT STAKEHOLDERS		
	PROJECT PARTICIPANTS	ORGANISATION
1	Client	Schwing Stetter (India) Pvt Limited, Chennai
2	Architect	Bhaskar Architects, Chennai
3	Structural Consultant	Tata Consulting Engineers Limited, Chennai
4	P.M.C	EPMCR, Chennai
5	Contractors	
a	Geotechnical Investigation	F.S. Engineering Pvt. Ltd., Chennai
b	Compound Wall & Land Developer (65%)	Shrusti, Chennai
c	Civil Works	Arun Excello, Chennai
d	Compound Wall (35%) & Machine Foundation Work	Samy Builders, Chennai
e	PEB Work	LLYOD Insulation (India) Ltd, Chennai
f	Mechanical & Fire fighting Work	Crescon Projects & Services Pvt. Ltd, Chennai
g	Electrical Work	Shakthi Electrical, Chennai
h	HVAC Work	C square, Chennai
i	Interior Work	Disha Interiors, Chennai
j	STP & ETP Works	Hubert, Chennai

KEY: In Study Scope Not in Study Scope

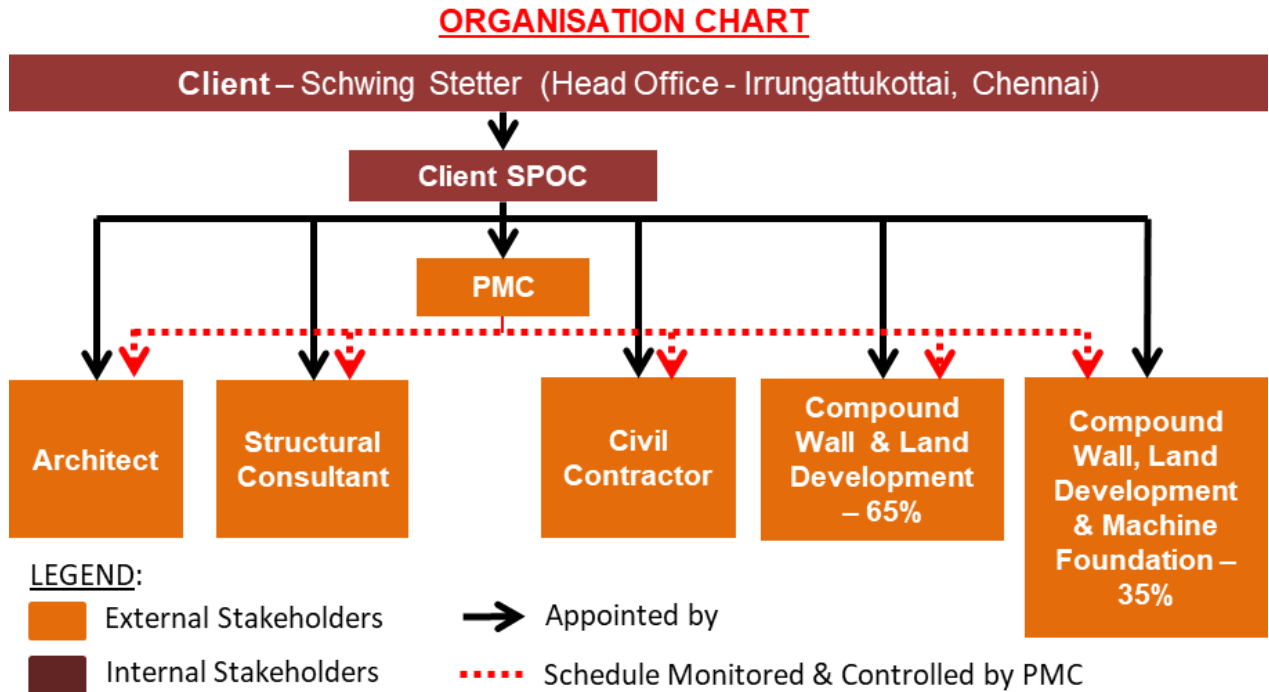


Fig 3.8 Organization Chart

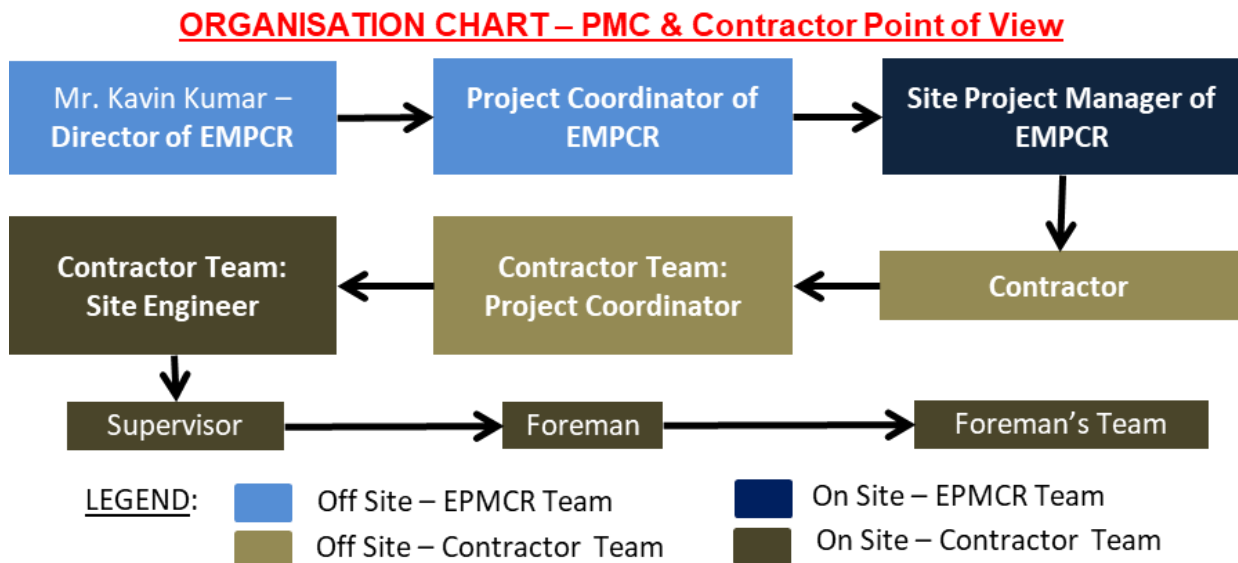


Fig 3.9 Organization Chart – PMC & Contractor Point of View

Table 3.15 Project Participants Stage of Appointment & their Level of Participation

CONSTRUCTION STAGE - PROJECT STAKEHOLDERS & THEIR STAGE OF APPOINTMENT (A) & STAGE OF PARTICIPATION (Colour Zone)									
PROJECT PARTICIPANTS		Stage 01	Stage 02	Stage 03	Stage 04	Stage 05	Stage 06		
1	Client	Schwing Stetter (India) Pvt Limited, Chennai							
3	Structural Consultant	Tata Consulting Engineers Limited, Chennai							
4	P.M.C	EPMCR, Chennai							
5	Contractors								
a	Geotechnical Investigation	F.S. Engineering Pvt. Ltd., Chennai	A						
b	Compound Wall & Land Developer (65%)	Shruti, Chennai	A						
c	Civil Works	Arun Excello, Chennai		A					
d	Compound Wall (35%) & Machine Foundation Work	Samy Builders, Chennai						Machine Foundation	Machine Installation
e	PEB Work	LLYOD Insulation (India) Ltd, Chennai				A			
f	Mechanical & Fire fighting Work	Crescon Projects & Services Pvt. Ltd, Chennai				A			
g	Electrical Work	Shakthi Electrical, Chennai				A			
h	HVAC Work	C square, Chennai						A	
i	Interior Work	Disha Interiors, Chennai						A	
j	STP & ETP Works	Hubert, Chennai							A
STAGE 01- Geotechnical Investigation		STAGE 04- Civil Footing Work & 25% Plinth Beam ; RCC Bldg- 1 st & 2 nd FL (Column, Slab							
STAGE 02- Compound & Land Development		& 2 nd floor Tie Beam and PEB Primary Member Installation							
STAGE 03- Civil Footing Work & 75% Plinth Beam ; RCC Bldg- GF		STAGE 05- Mezzanine Relocation, Machine foundation, GF floor work, PEB Completion							
Column		STAGE 06- Remaining bldg Services; Equip Installation & Interior & External Work Package							

3.2.4 Project Schedule – As Planned vs. As Built & Delay Duration

Table 3.16 Project Substructure Activities & Schedule (As Planned vs. As Built)- PEB Building & RCC Building

PEB BUILDING COMPARITIVE SCHEDULE FOR DELAY ANALYSIS (As Planned Vs. As Built)							
SI.No.	Activities – Common	Actual Planned Schedule	Actual Planned Duration	As Built Schedule	As Built Duration	Delay Duration	Responsibility
1	Geotechnical Investigation	20th Dec 2018 to 30th Dec 2018	10 days	20th Dec 2018 to 12th Jan 2019	22 days	12 days	Geotechnical Consultant
2	Site Office Compound Wall & Land Development (65% only completed)	1st March to 31st August 2019	184 days	1st March to 15th November 2019	260	76	Shruti
3	Rest 35 % - Land & Compound Wall Development	16th Nov 2018 to 1st June 2019	196	June 01 2019 (Bldg-1) Others - August and September	257 to 288	453 to 484	Samy
4	Appointment of Civil Contractor	1st June 2019	1	1st June 2019	1	-	Arun Excello
5	Building Approval & Site Handling	1st June 2019	-	19th Sep 2019	111	-	SIPCOT / Govt.
SI.No.	Activities – PEB Building	Actual Planned Schedule	Actual Planned Duration	As Built Schedule	As Built Duration	Delay Duration	Responsibility
FOOTING							
6	Footing Marking	Before 1 st delay : 20th Sep 2019 to 20th Oct 2019 After 1 st delay: 28th Sep 2019 to 22nd Nov 2019	Before 1 st delay: 30 days After 1 st delay: 63 days	28th Sep 2019 to 22nd Nov 2019	148 days	181 days	Owner; Arun Excello; Structural Consultant; Force Majeure
7	Footing Excavation						
8	Footing Soil Dressing						
9	Anti-Termite						
10	Footing Shuttering & PCC						
11	Footing Marking & Rebar Work –						
12	Footing & Pedestal						
12	Footing Shuttering						
13	Footing Concreting & Deshuttering						
PEDESTAL							
14	Pedestal Starter Marking	17th Oct 2018 to 9th Dec 2019	69 days	01st Nov 2019 to 2nd March 2020	95 days	83 days	Force Majeure
15	Pedestal Starter Shuttering & Concrete						
16	Pedestal -1st Lift Shuttering						
17	Pedestal -1st Lift Concrete						
18	Bolt Fixing						

Sl.No.	Activities – PEB Building	Actual Planned Schedule	Actual Planned Duration	As Built Schedule	As Built Duration	Delay Duration	Responsibility
19	Pedestal -2nd Lift Shuttering	17th Oct 2018 to 9th Dec 2019	69 days	01st Nov 19 to 2nd March 20	95 days	83 days	Force Majeure
20	Pedestal -2nd Lift Concrete						
FOOTING FILLING & COMPACTION							
16	Filling & Compaction Layer 01			10th Nov 2019 to 5th March 2020	95 days	123 days	Owner, Arun Excello; Force Majeure
17	Filling & Compaction Layer 02	27th Oct 2019 to 08th Jan 2020	73 days				
18	Filling & Compaction Layer 03						
PLINTH BEAM							
19	Plinth Beam Marking						
20	Plinth Beam Dressing						
21	Plinth Beam Shuttering & PCC						
22	Plinth Beam Marking						
23	Plinth Beam Reinforcement			15th Feb 2020 to 31st May 2020	106 days	147 days	Owner, Arun Excello; Force Majeure
24	Plinth Beam Shuttering	07 Dec 2019 to 26 Jan 2020	41 days				
25	Plinth Beam Concrete						

RCC BUILDING COMPARITIVE SCHEDULE FOR DELAY ANALYSIS (As Planned Vs. As Built)

Sl.No	Activities – RCC Inside Building	Actual Planned Schedule	Actual Planned Duration	As Built Schedule	As Built Duration	Delay Duration	Responsibility
FOOTING							
1	Footing Marking			Before Mezzanine Relocation: 10th Oct 2019 to 10th Feb 2020	Before Mezzanine Relocation: 122 days		
2	Footing Excavation						
3	Footing Soil Dressing						
4	Anti-Termite						
5	Footing Shuttering & PCC	28 th Sep 2019 to 22 nd Oct 2019	24 days	Mezzanine Relocation: 30th Sep 2020 to 13th Oct 2020	Mezzanine Relocation: 11 days	367 days	Owner, Arun Excello; Structural Consultant; Force Majeure
6	Footing Marking & Rebar Work –						
7	Footing & Pedestal						
8	Footing Shuttering						
	Footing Concreting & Deshuttering						

RCC BUILDING COMPARITIVE SCHEDULE FOR DELAY ANALYSIS (As Planned Vs. As Built)							
Sl.No	Activities – RCC Inside Building	Actual Planned Schedule	Actual Planned Duration	As Built Schedule	As Built Duration	Delay Duration	Responsibility
PEDESTAL							
9	Pedestal Starter Marking	17th Oct 2019 to 02nd Dec 2019	26 days	<u>Before Mezzanine Relocation:</u> 16th Nov 2019 to 21st <u>Mezzanine Relocation:</u> 13th Oct 2020 to 26th Oct 2020	<u>Before Mezzanine Relocation:</u> 87 days <u>Mezzanine Relocation:</u> 13 days	374 days	Arun Excello (Labour Availability); Force Majeure
10	Pedestal Starter Shuttering & Concrete						
11	Pedestal Shuttering						
12	Pedestal Concrete						
FOOTING FILLING & COMPACTION							
13	Filling & Compaction	30th Oct 2019 to 8th Nov 2019	9 days	<u>Before Mezzanine Relocation:</u> 30th Nov 2019 to 24th Feb 2020 <u>Mezzanine Relocation:</u> 26th Oct 2019 to 29th Oct 2019	<u>Before Mezzanine Relocation:</u> 88 days <u>Mezzanine Relocation:</u> 4 days	364 days	Arun Excello; (Material & labour availability); Force Majeure Owner
PLINTH BEAM							
14	Plinth Beam Marking	04th Nov 2019 to 24th Nov 2019	20 days	<u>Before Mezzanine Relocation:</u> 07th Dec 2019 to 2nd Mar 2020 <u>Mezzanine Relocation:</u> 29th Oct 2020 to 2nd Nov 2020	<u>Before Mezzanine Relocation:</u> 85 days <u>Mezzanine Relocation:</u> 5 days	367 days	Owner, Arun Excello; Force Majeure
15	Plinth Beam Dressing						
16	Plinth Beam Shuttering & PCC						
17	Plinth Beam Marking						
18	Plinth Beam Reinforcement & Shuttering						
19	Plinth Beam Concrete						

Table 3.17 Project Substructure Schedule and Reason for Delay (As Planned vs. As Built) - PEB Building & RCC Building

OVERALL DELAY REASONS (As Planned Vs. As Built)							
Sl.No.	Activities – Common	Actual Planned Schedule	Actual Planned Duration	As Built Schedule	As Built Duration	Delay Duration	Responsibility
1	Geotechnical Investigation	20th Dec 2018 to 30th Dec 2018	10	20th Dec 2018 to 12th Jan 2019	22	12	Geotechnical Consultant
DELAY REASON: 2 Auger drill rig Required, But they bought only 1 No							
2	Site Office Compound Wall & Land Development (65% only completed)	1st March to 31st August 2019	184	1st March to 15th November 2019	260	76	Shruti
DELAY REASON: - Inadequate Manpower - Lack of planning of activity - No Quality of work - Though highlighted by PMC Team, delay are not taken into consideration by shruti. - Lack of effective response since client and shruti are friends, they were lethargic							
3	Rest 35 % - Land & Compound Wall Development	16th Nov 2018 to 1st June 2019	196	June 01 2019 (Bldg-1) Others - August and September	257 to 288	453 to 484	Swami
DELAY REASON: - Less work productivity - Rain							
4	Appointment of Civil Contractor	1st June 2019	1	1st June 2019	1	-	Arun Excello
5	Building Approval & Site Handling	1st June 2019	-	19th Sep 2019	111	-	SIPCOT / Govt.
DELAY REASON: It's a DC Land, So approval from the government got delayed since the landowner demanded on high cost on exchange.							

OVERALL DELAY REASONS (As Planned Vs. As Built)					
Sl.NO.	ACTIVITIES	As Planned Schedule	As Planned Duration	As Built Schedule	As Built Duration
PEB	Footing	Before 1 st delay : 20th Sep 2019 to 20th Oct 2019 After 1 st delay: 28th Sep 2019 to 22nd Nov 2019	Before 1 st delay: 30 days After 1 st delay: 63 days	28th Sep 2019 to 22nd Nov 2019	148 days
RCC	Footing	28th Sep 2019 to 22nd Oct 2019	24 days	10th Oct 2019 to 10th Feb 2020	122 days
	RCC – Mezzanine add-on	30th Sep 2020 to 13th Oct. 2020	11 days	30th Sep 2020 - 13th Oct 2020	11 days

DELAY REASON:

- Change of footing sizes as civil contractor asked for similar sizes of footings for shuttering repetitions and reduced cost and material for shuttering.
- Wait for structural output for new scope
- Lack of coordination between architecture and structural drawing for footing allocation which required change in drawing.
- As per contractor schedule: 1 month
- Hard Rock level while excavation found to be prior than what was determined earlier around 1m they have to remove / Scrap the hard rock
- Out of 137 footings -65%, 85 Nos. Were to scrapped
- Footing scope reduced from 6 to 4 Nos per day as hard rock scrapping and seepage removal took additional 2 hours per day.
- While Excavation ground water seepage occurred, lead to need of dewatering -footing scope again reduced from 4 to 3 to 2 Nos per day as seepage removal took additional 2 hours per day.
- Lack of labor availability (25 out of 75 were only available)
- 1 month previously estimated became 2 months

DELAY REASON 02:

- Heavy Rain from September till November end
- Site Access Restriction- Low lying area at site
- Excavated footings filled by surrounding site rain water.
- Lack of skilled labor- bar bender
- Rain has also led to wastage of labor as many were ideal resources

OVERALL DELAY REASONS (As Planned Vs. As Built)					
Sl.NO.	ACTIVITIES	As Planned Schedule	As Planned Duration	As Built Schedule	As Built Duration
PEB	Pedestal	17th Oct 2018 to 9th Dec 2019	69 days	01st Nov 2019 to 2nd March 2020	95 days
RCC	Pedestal	17th Oct 2019 to 02nd Dec 2019	26 days	16th Nov 2019 to 21st Dec 2020	374 days
	Pedestal- Mezzanine Relocation	13th Oct 2020 to 26th Oct 2020	13 days	13th Oct 2020 to 26th Oct 2020	13 days
DELAY REASON: Continuous Rain					
PEB	Footing Filling & Compaction	27th Oct 2019 to 08th Jan 2020	73 days	10th Nov 2019 to 5th March 2020	123 days
RCC	Footing Filling & Compaction	30th Oct 2019 to 8th Nov 2019	9 days	30th Nov 2019 to 24th Feb 2020	88 days
	Footing Filling & Compaction -Mezzanine Relocation	26th Oct 2019 to 29th Oct 2019	4 days	26th Oct 2019 to 29th Oct 2019	4 days
DELAY REASON:					
- Rain - Availability of Material (Top Soil removed are used in other site as other site is in priority to this)					
PEB	Plinth Beam	07 Dec 2019 to 26 Jan 2020	41 days	15th Feb 2020 to 31st May 2020	106 days
RCC	Plinth Beam	04th Nov 2019 to 24th Nov 2019	20 days	07th Dec 2019 to 2nd Mar 2020	85 days
	Plinth Beam-Mezzanine add-on	29th Oct 2020 to 2nd Nov 2020	5 days	29th Oct 2020 to 2nd Nov 2020	5 days
DELAY REASON:					
- More priority to other building leading to:- lack of labor allotted here (25 were only available out of 75 required number)- lack of planning - Low lying area compared to other building leading to rain water stagnant till dec 15, 2019. - Initial Estimated Plinth beam running Meter per day of 30m / day was reduced to 21m to 22m /day - No site access for RCC Truck movement - Covid 19 after 75% Plinth beam Completed, Rest 25% got delayed and started only at 11th May 2020 and Completed by 31st May 2020. - Less no. of skilled labor (bar bender) availability					

3.2.5 Site Photographs



Fig 3.10 Overall Construction Process

CONSTRUCTION PROCESS – SITE PHOTOGRAPHS



Footing-Excavation Process



Footing-Rebar work Process



Footing-Concreting Process



RCC Bldg Pedestal-Shuttering & Concreting



**PEB Pedestal 1st Lift -
Concreting**



**PEB Pedestal 2nd Lift
Bolt Fixing**



**PEB Pedestal 2nd Lift -
Concreting**



RCC Bldg Pedestal-Shuttering



RCC Bldg Pedestal-Concreting



Plinth Beam- Shuttering & Concreting

Fig 3.11 Substructure Construction Process

CHAPTER 4 ANALYSIS AND RESULT

4.1 ANALYSIS

4.1.1 Project as Planned Schedule after 1st Delay (PEB Bldg.)

Table 4.1 Project as Planned Schedule (PEB Building)

S/NO.	ACTIVITIES – PEB Building	Days	As Planned Start	As Planned Finish	Dependency
FOOTING					
A					
1	Footing Marking	30	28-09-19	27-10-19	
2	Footing Excavation	30	29-09-19	28-10-19	1SS+1
3	Footing Soil Dressing	30	01-10-19	30-10-19	2SS+2
4	Anti-Termite	30	02-10-19	31-10-19	3SS+1
5	Footing Shuttering & PCC	30	02-10-19	31-10-19	4SS
6	Footing Marking	30	04-10-19	02-11-19	5SS+2
7	Footing Rebar Work – Footing & Pedestal	30	07-10-19	05-11-19	6SS+3
8	Footing Shuttering	30	11-10-19	09-11-19	7SS+4
9	Footing Concreting & Deshuttering	40	14-10-19	22-11-19	8SS+3
PEDESTAL					
B					
10	Pedestal Starter Marking	40	17-10-19	25-11-19	9SS+3
11	Pedestal Starter Shuttering & Concrete	40	18-10-19	26-11-19	10SS+1
12	Pedestal -1st Lift Shuttering	40	20-10-19	28-11-19	11SS+2
13	Pedestal -1st Lift Concrete	40	23-10-19	01-12-19	12SS+3
14	Bolt Fixing	40	26-10-19	04-12-19	13SS+3
15	Pedestal -2nd Lift Shuttering	40	28-10-19	06-12-19	14SS+2
16	Pedestal -2nd Lift Concrete	40	31-10-19	09-12-19	15SS+3
FILLING & COMPACTION					
C					
17	Footing Filling & Compaction Layer	20	27-10-19	15-11-19	14SS+1
18	Pedestal Filling & Compaction Layer 01	30	10-11-19	09-12-19	16SS+10, 17SS+14
19	Pedestal Filling & Compaction Layer 02	40	20-11-19	29-12-19	18SS+10
20	Pedestal Filling & Compaction Layer 03	40	30-11-19	08-01-20	19SS+10
PLINTH BEAM					
D					
21	Plinth Beam Marking	40	06-12-19	14-01-20	20SS+6
22	Plinth Beam Dressing	40	07-12-19	15-01-20	21SS+1
23	Plinth Beam Shuttering & PCC	40	08-12-19	16-01-20	22SS+1
24	Plinth Beam Marking	40	09-12-19	17-01-20	23SS+1
25	Plinth Beam Reinforcement	40	11-12-19	19-01-20	24SS+2
26	Plinth Beam Shuttering	40	15-12-19	23-01-20	25SS+4
27	Plinth Beam Concrete	40	18-12-19	26-01-20	26SS+3

PROJECT AS PLANNED SCHEDULE – PEB BUILDING

4.1.2 Project as Planned Schedule after 1st Delay (RCC Bldg.)

Table 4.2 Project as Planned Schedule (RCC Building)

PROJECT AS PLANNED SCHEDULE – RCC BUILDING (ELECTRONIC ROOM, TOILET BLOCK, MEZZANINE AREA)						
Sl.NO.	ACTIVITIES – PEB Building	Days	As Planned Start	As Planned Finish	Dependency	
A	FOOTING					
1	Footing Marking	7	28-09-19	05-10-19		
2	Footing Excavation	7	29-09-19	06-10-19	1SS+1	
3	Footing Soil Dressing	7	01-10-19	07-10-19	2SS+2	
4	Anti-Termite	7	02-10-19	08-10-19	3SS+1	
5	Footing Shuttering & PCC	7	03-10-19	09-10-19	4SS+1	
6	Footing Marking	7	04-10-19	10-10-19	5SS+1	
7	Footing Rebar Work – Footing & Pedestal	10	05-10-19	14-10-19	6SS+1	
8	Footing Shuttering	10	08-10-19	17-10-19	7SS+3	
9	Footing Concreting & Deshuttering	10	13-10-19	22-10-19	8SS+5	
B	PEDESTAL					
10	Pedestal Starter Marking	7	17-10-19	23-10-19	9SS+4	
11	Pedestal Starter Shuttering & Concrete	7	18-10-19	24-10-19	10SS+1	
12	Pedestal Shuttering	7	21-10-19	27-10-19	11SS+3	
13	Pedestal Concrete	10	24-10-19	02-11-19	12SS+3	
C	FOOTING FILLING & COMPACTION					
14	Filling & Compaction	10	30-10-19	08-11-19	13SS+6	
D	PLINTH BEAM					
15	Plinth Beam Marking	7	04-11-19	10-11-19	14SS+5	
16	Plinth Beam Dressing	7	05-11-19	11-11-19	15SS+1	
17	Plinth Beam Shuttering & PCC	7	06-11-19	12-11-19	16SS+1	
18	Plinth Beam Marking	7	07-11-19	13-11-19	17SS+1	
19	Plinth Beam Reinforcement & Shuttering	7	10-11-19	16-11-19	18SS+3	
20	Plinth Beam Concrete	12	13-11-19	24-11-19	19SS+3	

4.1.3 Meetings & Reporting as Per Conventional Planning System – Implemented Here & Footing Typologies with Dimension

MEETINGS & REPORTINGS AS PER CONVENTIONAL PLANNING SYSTEM – IMPLEMENTED HERE:				
Meeting & Reporting based on Scheduling	Occurrence	Purpose	Participants	
Monthly Meeting	• NIL	• NIL	• NIL	
Weekly Meeting	• Mostly at end of the week • Weekly report – EPMCR	• Weekly Progress to EPMCR & Others Involved in the meeting • Issue discussion • Things to Achieve next week • Backlogs & Challenges & Solution	• EPMCR • Client • Contractor (Civil & PEB) • Subcontractor If design changes / inputs required: • Architect & • Structural Consultants	
Weekly (Tuesday)	• Tuesday	• MEP Coordination & Upcoming Work • Work Progress	• EPMCR • MEP Contractor	
Daily Meeting	• Not effectively done but Daily Record was maintained - DPR	• DPR	• EPMCR – Site Project Manager (Mr.Sravan)	

FOOTING TYPOLOGY, DIMENSION & REPITITIONS – ANALYSIS:									
PEDESTAL NUMBERS	FOOTING DIMENSION				COLUMN NUMBERS	FOOTING DIMENSION			
	L	B	D1	D1		L	B	D1	D1
P1	3600	3100	600	600	C1	3100	2250	625	625
P1A, FC1	3600	3100	600	600	C2	2250	1950	525	525
P2	4200	3300	650	650	C3	2250	1950	500	500
P3	4300	3600	650	650	C4	2550	2550	600	600
P4	2200	2000	450	450	C5	2000	1700	475	475
P5	3300	2800	700	700	C6	1900	1600	450	450
P5A	3200	2900	750	750	C7	4100	3450	900	900
P6	3800	3200	750	750	C8	4100	3450	875	875
P7, P8	4600	3800	750	750	C9	1900	1600	450	450
P9	3500	3000	750	750	C10	2200	1900	525	525
P10	3200	2800	700	700	C11	1800	1500	425	425
P11	3200	2800	650	650	C12	4050	3650	775	775
P12	3600	3100	500	500	C14	2550	2100	575	575
P12A	3500	2500	450	450	C15	2800	2700	625	625
C13	1500	1200	400	400	C16	1800	1500	425	425
					C17	2550	2100	575	575

Fig 4.1 Meeting Held Here & Participants & Footing Typologies & Dimension

4.1.4 Executed Footing Typology & Work Flow Direction – Color Code

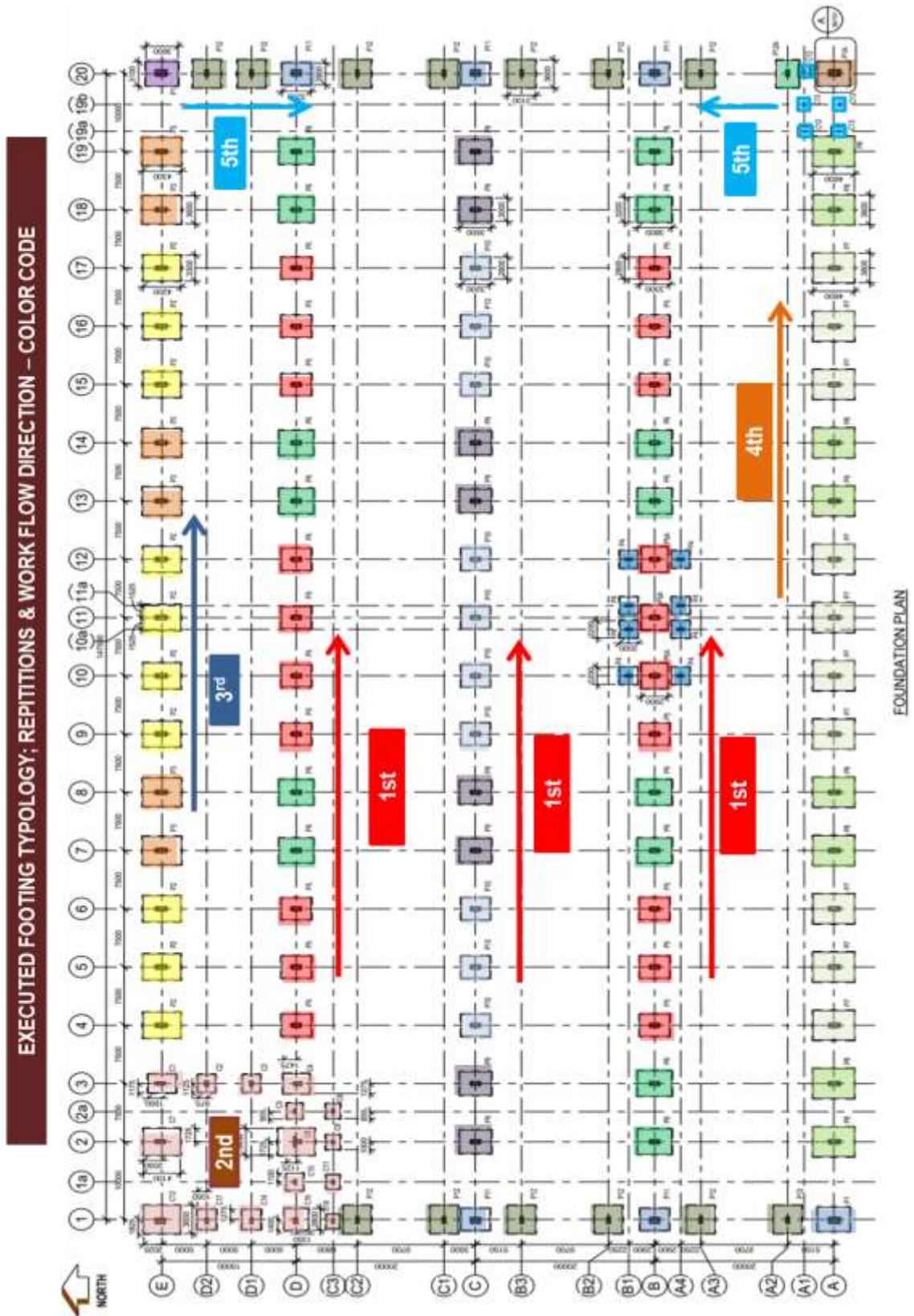


Fig 4.2 Footing Typologies & Dimension with Color Code

4.1.5 Foundation Details

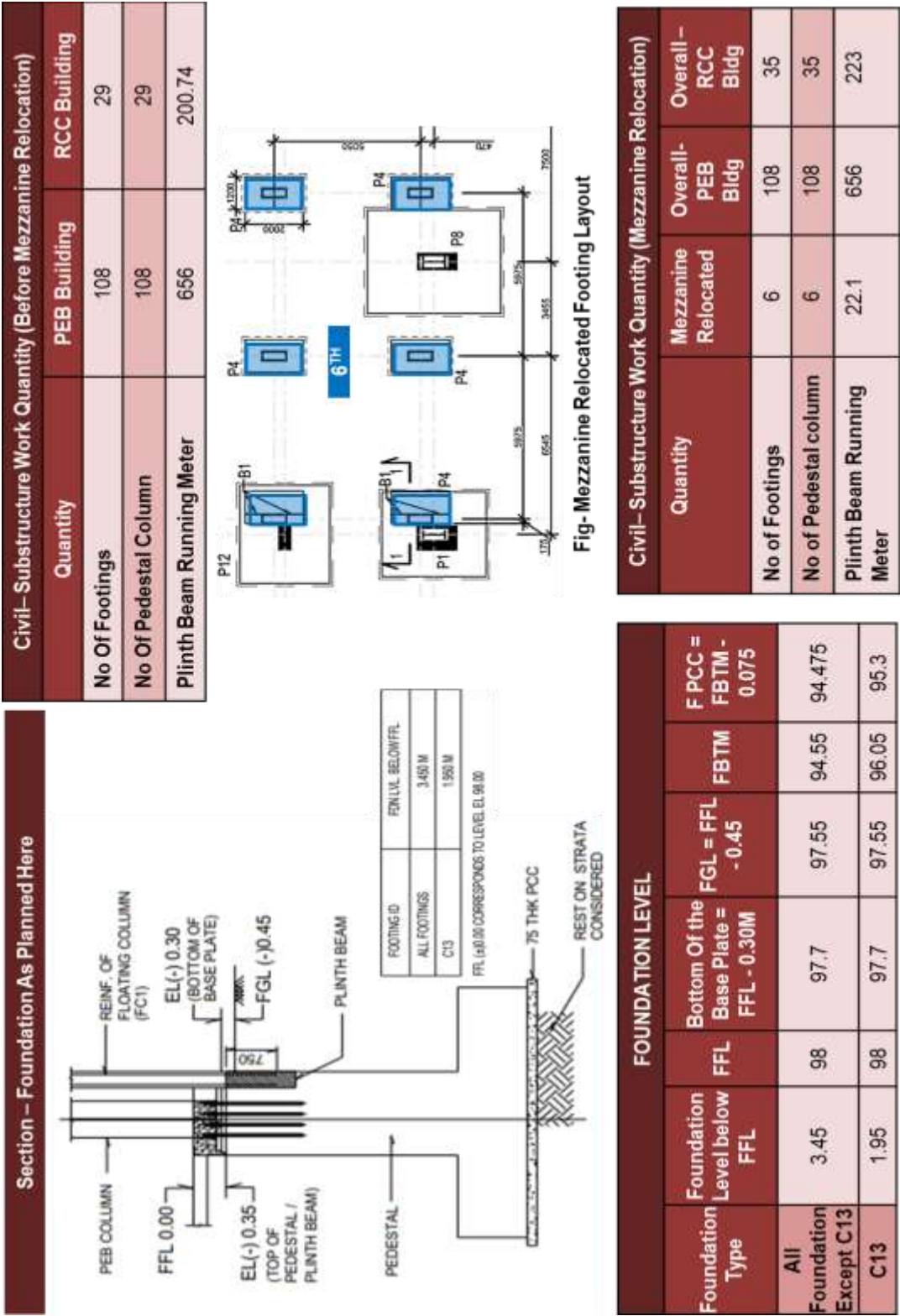


Fig 4.3 Footing Details & Dimension

4.1.6 Substructure Civil Work- Cycle Time Baseline

Table 4.3 Substructure Civil Work- Cycle time Baseline

CYCLE TIME BASELINE							
SL. No.	ACTIVITY	Cycle time -		Total Quantity	Calculated for	Calculation Range -Quantity / day	
		Min	time - Hr			Lowest	Highest
FOOTING							
1	Footing Marking	15	0.25	143 No	1 No	8.5m	35m
2	Footing Excavation (JCB Bucket Efficiency - 0.6 Cum. & Excavator bucket Efficiency - 0.9 Cum with bucket timing 5 mins &for Hard Rock - 65% Footings(0.5m- 30min ; 1.5m- 1 hr ; below 1.5m: 2 hr)	180	3	143 No	1 No	4.05 Cum	59 Cum
3	Footing Soil Dressing (Dressing 30 mins & Vibrator - 45 mins)	45	0.75	143 No	1 No	0.132 Cum	0.176 Cum
4	Footing Shuttering & PCC (Survey Marking- 5 mins; Shuttering Allignment - 10 mins & PCC - 15 Mins)	30	0.5	143 No	1 No	Footing PCC size & Vol = 2.2*2*0.075= 0.33 Cum	Footing PCC size & Vol = 4.6*3.8*0.075 = 13.11 Cum
6	Footing Shuttering (Bord fixing 4 sides - 15 mins ; Support fixing- 1hr 30 mins & Work Front - 15 mins)	120	2	143 No	1 No	Footing size (m) = 2.2*2*0.45	Footing PCC size (m) = 4.6*3.8*0.75
7	Footing Concrete (depth divided into 2 and done In 2 Layers - each layer 1 hour Including pouring dragging; Vibrator & Work front)	120	2	143 No	1 No	Concreting Vol= 1.98 Cum; Each Layer = 0.99 Cum	Concreting Vol = 13.11 Cum; Each Layer = 6.5 Cum
PEDESTAL							
9	Pedestal Starter Marking, Shuttering & Concrete (Marking- 15 mins; Shuttering - 15 mins; Concreting- 15 mins & Work front- 15 mins)	60	1	143 No	1 No	Pedestal Concrete size = 0.45*0.2*0.1= 0.009 Cum	Pedestal Concrete size = 1.15*0.4*0.1= 0.046 Cum
10	Pedestal -1st Lift Shuttering (Board fixing & support fixing - 1 hr 30 mins)	90	1.5	143 No	1 No	Pedestal Shuttering size (m) = 0.45*0.2*1	Pedestal Shuttering size(m)= 1.15*0.4*2.475

CYCLE TIME BASELINE							
SL. No.	ACTIVITY	Cycle time -		Total Quantity	Calculated for	Calculation Range -Quantity / day	
		Min	time - Hr			Lowest	Highest
11	Pedestal -1st Lift Concrete (Pouring & Vibrator - 30 mins)	30	0.5	143 No	1 No	Pedestal Concrete Vol = 0.45*0.2*1= 0.09 Cum	Pedestal Concrete Vol = 1.15*0.4*2.475= 1.1385 Cum
12	Bolt Fixing + Checking	240	4	143 No	1 No		
13	Pedestal -2nd Lift Shuttering (Board fixing & support fixing - 1 hr 30 mins)	90	1.5	143 No	1 No	Pedestal Shuttering size (m) = 0.45*0.2*1	Pedestal Shuttering size(m)= 1.15*0.4*2.475
14	Pedestal -2nd Lift Concrete (Pouring & Vibrator - 30 mins)	30	0.5	143 No	1 No	Pedestal Concrete Vol = 0.45*0.2*1= 0.09 Cum	Pedestal Concrete Vol = 1.15*0.4*2.475= 1.1385 Cum
BACK FILLING							
15	Footing Backfilling (Backfilling, Compacting & Workfront)	45	0.75	143 No	1 No	Footing Backfilling Vol = 0.36 Cum	Footing Backfilling Vol = 14.336 Cum
16	Pedestal -1st Lift Backfilling (Backfilling, Compacting & Workfront)	180	3	143 No	1 No	Pedestal Backfilling for 1 lift Vol = 0.45*0.2*1= 0.09 Cum	Pedestal Backfilling for 1 lift Vol = 0.45*0.2*1= 0.09 Cum
17	Pedestal -2nd Lift Backfilling (Backfilling, Compacting & Workfront)	180	3	143 No	1 No		
PLINTH BEAM							
18	Plinth Beam Shuttering & PCC (Shuttering - 30 mins, PCC - 30 mins)	60	1	879m	7 m		0.105 Cum
20	Plinth Beam Shuttering (Bord fixing 4 sides - 15 mins ; Support fixing with work front- 1hr 45 mins)	120	2	879m	7 m		1.26 Cum
21	Plinth Beam Concrete (Pouring & Vibrator - 60 mins)	60	1	879m	7 m		1.26 Cum

4.1.7 Cycle Time Calculation, Work Scope per Day And Total Duration

Table 4.4 Substructure Civil Work- Cycle time Calculated, Work scope per Day & Total Duration before Delay 01

ACTIVITY CYCLE TIME CALCULATION; WORK SCOPE PER DAY PLANNING & DELAY HOURS										
SL.NO.	ACTIVITIES	Cycle time per Footing Per day			Cycle time for As Preliminary Schedule - Average Hr / day	Activity Predecessor	Total Quantity	As Planned -Preliminary		
		Cycle time -		Days/ Activity				No or Meter / day		
		Min	Cycle time - Hr				Calculated For			
FOOTING										
1	Footing Marking	15	0.25	1 No	1.5		143 Nos	23	6 Nos	
2	Footing Excavation	180	3	1 No	18	1	143 Nos	23	6 Nos	
3	Footing Soil Dressing	45	0.75	1 No	4.5	2	143 Nos	23	6 Nos	
4	Footing Shuttering & PCC	30	0.5	1 No	3	3	143 Nos	23	6 Nos	
5	Footing Marking & Rebar	195	3.25	1 No	19.5	4	143 Nos	23	6 Nos	
6	Footing Shuttering	120	2	1 No	12	5	143 Nos	23	6 Nos	
7	Footing Concrete (In 2 Layers)	120	2	1 No	12	6	143 Nos	23	6 Nos	
PEDESTAL										
8	Pedestal Rebar work	180	3	1 No	18	7	143 Nos	23	6 Nos	
9	Pedestal Starter Marking, Shuttering & Concrete	60	1	1 No	6	8	143 Nos	23	6 Nos	
10	Pedestal -1st Lift Shuttering	90	1.5	1 No	9	9	143 Nos	23	6 Nos	
11	Pedestal -1st Lift Concrete	30	0.5	1 No	3	10	143 Nos	23	6 Nos	
12	Bolt Fixing + Checking	240	4	1 No	24	11	143 Nos	23	6 Nos	
13	Pedestal -2nd Lift Shuttering	90	1.5	1 No	9	12	143 Nos	23	6 Nos	
14	Pedestal -2nd Lift Concrete	30	0.5	1 No	3	13	143 Nos	23	6 Nos	
SOIL BACK FILLING										
15	Footing Backfilling	45	0.75	1 No	4.5	14	143 Nos	23	6 Nos	
16	Pedestal -1st Lift Backfilling	180	3	1 No	18	15	143 Nos	23	6 Nos	
17	Pedestal -2nd Lift Backfilling	180	3	1 No	18	16	143 Nos	23	6 Nos	
PLINTH BEAM										
18	Plinth Beam Shuttering & PCC	60	1	7 m	4.3	17	879m	30	30m	
19	Plinth Beam Rebar work	180	3	7 m	13	18	879m	30	30m	
20	Plinth Beam Shuttering	120	2	7 m	8.5	19	879m	30	30m	
21	Plinth Beam Concrete	60	1	7 m	4.3	20	879m	30	30m	

Table 4.5 Substructure Civil Work- Cycle time Calculated, Work scope per Day & Total Duration after Delay 01

ACTIVITY CYCLE TIME CALCULATION; WORK SCOPE PER DAY PLANNING & DELAY HOURS									
SL.NO.	ACTIVITIES	Cycle time per Footing Per day			As Planned - Revised After 1st Delay		Cycle time for As Revised Schedule After Delay 01 - Average Hr / day	Remaining Hour spent on Extracting Hard rock / Dewatering & Other Delay	
		Cycle time - Min	Cycle time - Hr	Calculated For	Days/ Activity	No or Meter / day			
FOOTING									
1	Footing Marking	15	0.25	1 No	30	4 Nos	1	0.5	
2	Footing Excavation	180	3	1 No	30	4 Nos	12	6	
3	Footing Soil Dressing	45	0.75	1 No	30	4 Nos	3	1.5	
4	Footing Shuttering & PCC	30	0.5	1 No	30	4 Nos	2	1	
5	Footing Marking & Rebar	195	3.25	1 No	30	4 Nos	13	6.5	
6	Footing Shuttering	120	2	1 No	30	4 Nos	8	4	
7	Footing Concrete (In 2 Layers)	120	2	1 No	30	4 Nos	8	4	
PEDESTAL									
8	Pedestal Rebar work	180	3	1 No	40	3 Nos	9	9	
9	Pedestal Starter Marking, Shuttering & Concrete	60	1	1 No	40	3 Nos	3	3	
10	Pedestal -1st Lift Shuttering	90	1.5	1 No	40	3 Nos	4.5	4.5	
11	Pedestal -1st Lift Concrete	30	0.5	1 No	40	3 Nos	1.5	1.5	
12	Bolt Fixing + Checking	240	4	1 No	40	3 Nos	12	12	
13	Pedestal -2nd Lift Shuttering	90	1.5	1 No	40	3 Nos	4.5	4.5	
14	Pedestal -2nd Lift Concrete	30	0.5	1 No	40	3 Nos	1.5	1.5	
SOIL BACK FILLING									
15	Footing Backfilling	45	0.75	1 No	20	7 Nos	5.25	-0.75	
16	Pedestal -1st Lift Backfilling	180	3	1 No	40	3 Nos	9	9	
17	Pedestal -2nd Lift Backfilling	180	3	1 No	40	3 Nos	9	9	
PLINTH BEAM									
18	Plinth Beam Shuttering & PCC	60	1	7 m	40	21m	3	1.3	
19	Plinth Beam Rebar work	180	3	7 m	40	21m	9	4	
20	Plinth Beam Shuttering	120	2	7 m	40	21m	6	2.5	
21	Plinth Beam Concrete	60	1	7 m	40	21m	3	1.3	

4.1.8 Labor Requirement Per Day & Labor Availability

Table 4.6 Labor Requirement

LABOUR REQUIREMENT			
SI.NO.	ACTIVITIES	Labour Requirement per Day	
		Description	Quantity
1	Footing Marking	Surveyor	1
2	Footing Excavation & Soil Dressing	JCB / Excavator + Soil Dressing Team	3
4	Footing Shuttering & PCC	Concrete Team	1
5	Footing Marking & Rebar Work	Barbender Team	2
6	Footing Shuttering & Concrete	Carpenter Team	3
7	Footing Deshuttering & Backfilling	Backfilling Team	6
8	Pedestal Rebar work	Barbender Team + Welder	2
9	Pedestal Starter Concrete	Carpenter + Helper	1
10	Pedestal -1st Lift Shuttering & Concrete	Carpenter Team+ Concrete Team	2
11	Pedestal -1st Lift Backfilling	Backfilling Team	2
12	Pedestal -2nd Lift Concrete	Carpenter Team+ Concrete Team	2
13	Pedestal -2nd Lift Backfilling	Backfilling Team	2
14	Plinth Beam Marking & Excavation	Surveyor+ Excavation	2
15	Plinth Beam Shuttering & PCC	Carpenter+ Concrete Team	2
16	Plinth Beam Marking & Rebar work with SC	Barbender Team	2
17	Plinth Beam Shuttering & Concrete	Carpenter+ Concrete Team	2

Table 4.7 Labor Typology & Labor Required vs. Available

LABOUR INVOLVED IN THE TEAM			LABOUR REQUIRED PER DAY			
Sl. No.	Team	Labors Typology Involved	Sl. No.	Labour Typology	Required / Day	Available / Day
1	Surveyor Team	Surveyor + Helper	1	Surveyor	1	1
2	Soil Dressing Team	Excavator + M/C	2	Barbender	16	5
3	Barbender Team	Barbender + Helper	3	Helper	12	3
4	PCC Team	Mason + M/C	4	Mason	14	1
5	RCC Team	Mason + M/C	5	M/C	16	3
6	Shuttering Team	Carpenter + Helper	6	Carpenter	20	4
7	Curing Team	M/C	7	Excavator	1	1
8	Excavator Team	Excavator	TOTAL QUANTITY		80	18
9	Backfilling Team	M/C				

LEGEND	
DESCRIPTION	KEY
Available as Required	
Not Available as Required	

4.1.9 Equipment Availability & Cycle Time As Planned Vs. As Built

Table 4.8 Equipment Availability & Cycle Time As Planned vs. As Built

AS PLANNED Vs. EXECUTED - WORK SCOPE PER DAY PLANNING & BACKLOG						
SL.NO.	Activities	Activity Predecessor	Total Quantity	As Planned Work Scope per day- Revised After 1st Delay	As Built - Scope of Work per day	Backlog per day
FOOTING						
1	Footing Marking		143 Nos	4 Nos	1 to 2 Nos.	3 to 2 Nos.
2	Footing Excavation	1	143 Nos	4 Nos	1 to 2 Nos.	3 to 2 Nos.
3	Footing Soil Dressing	2	143 Nos	4 Nos	1 to 2 Nos.	3 to 2 Nos.
4	Footing Shuttering & PCC	3	143 Nos	4 Nos	1 to 2 Nos.	3 to 2 Nos.
5	Footing Marking & Rebar Work	4	143 Nos	4 Nos	1 to 2 Nos.	3 to 2 Nos.
6	Footing Shuttering	5	143 Nos	4 Nos	1 to 2 Nos.	3 to 2 Nos.
7	Footing Concrete (In 2 Layers)	6	143 Nos	4 Nos	1 to 2 Nos.	3 to 2 Nos.
PEDESTAL						
8	Pedestal Rebar work	7	143 Nos	3 Nos	2 to 3 Nos.	1 Nos.
9	Pedestal Starter Marking, Shuttering & Concrete	8	143 Nos	3 Nos	2 to 3 Nos.	1 Nos.
10	Pedestal -1st Lift Shuttering	9	143 Nos	3 Nos	1 to 3 Nos.	1 to 2 Nos.
11	Pedestal -1st Lift Concrete	10	143 Nos	3 Nos	1 to 3 Nos.	1 to 2 Nos.
12	Bolt Fixing + Checking	11	143 Nos	3 Nos	1 to 3 Nos.	1 to 2 Nos.
13	Pedestal -2nd Lift Shuttering	12	143 Nos	3 Nos	1 to 3 Nos.	1 to 2 Nos.
14	Pedestal -2nd Lift Concrete	13	143 Nos	3 Nos	1 to 3 Nos.	1 to 2 Nos.
SOIL BACK FILLING						
15	Footing Backfilling	14	143 Nos	7 Nos	7 Nos	Nil
16	Pedestal -1st Lift	15	143 Nos	3 Nos	3 Nos	Nil
17	Pedestal -2nd Lift	16	143 Nos	3 Nos	3 Nos	Nil
PLINTH BEAM						
18	PB Shuttering & PCC	17	879m	21m	17 - 21 m	4 m
19	PB Rebar work	18	879m	21m	17 - 21 m	4 m
20	PB Shuttering	19	879m	21m	17 - 21 m	4 m
21	PB Concrete	20	879m	21m	17 - 21 m	4 m

EQUIPMENT / MACHINERIES REQUIRED PER DAY			
Sl. No.	Equipment / Machineries	Required / Day	Available / Day
1	Excavator (0.9 Cum.) with Breaker for Hardrock	1	1
	JCB (0.6 Cum.)	1	1
2	Tipper	3	3
3	RMC Truck - 6 to 9 Cum	1	1
4	Augur - Soil Test	2	1
5	Dewatering Pump 5 HP - 3 Mins	4	1
6	Vibrator	1	1
6	Earth Rammer	1	1
TOTAL QUANTITY		13	9

LEGEND	
DESCRIPTION	KEY
Available as Required	
Not Available as Required	

LEGEND	
DESCRIPTION	KEY
Delay Due to Hard Rock, Drawing revision, Response delay & Coordination	FONT
Delay due to rain, dewatering - Rain & Seepage Ground Water & other delay	FONT
No delay	FONT

4.1.10 As Planned Cycle Time Per Day Before & After Delay 01 And Duration Wastage

Table 4.9 As Planned Cycle Time Per Day Before & After Delay 01 And Duration Wastage – Quantitative Findings

AS PLANNED CYCLE TIME PER DAY BEFORE DELAY 01 & AFTER DELAY 01 AND DURATION WASTAGE									
SL.NO.	ACTIVITIES	Activity Predecessor	Total Quantity	As Planned - Revised After 1st Delay		As Planned Cycle Time Before Delay 01 for 6 Footing or 30 meter Plinth Beam Per Day	Cycle time for As Revised Schedule After Delay 01 - Average Hr / day	Duration Wastage in respect to As Planned Schedule before 1st delay - 6 Footings or 30M PB per day	
				Days/ Activity	No or Meter / day				
FOOTING									
1	Footing Marking		143 Nos	30	4 Nos	1.5	1	0.5	
2	Footing Excavation	1	143 Nos	30	4 Nos	18	12	6	
3	Footing Soil Dressing	2	143 Nos	30	4 Nos	4.5	3	1.5	
4	Footing Shuttering & PCC	3	143 Nos	30	4 Nos	3	2	1	
5	Footing Marking & Rebar	4	143 Nos	30	4 Nos	19.5	13	6.5	
6	Footing Shuttering	5	143 Nos	30	4 Nos	12	8	4	
7	Footing Concrete (in 2 Layers)	6	143 Nos	30	4 Nos	12	8	4	
PEDESTAL									
8	Pedestal Rebar work	7	143 Nos	40	3 Nos	18	9	9	
9	Pedestal Starter Marking, Shuttering & Concrete	8	143 Nos	40	3 Nos	6	3	3	
10	Pedestal -1st Lift Shuttering	9	143 Nos	40	3 Nos	9	4.5	4.5	
11	Pedestal -1st Lift Concrete	10	143 Nos	40	3 Nos	3	1.5	1.5	
12	Bolt Fixing + Checking	11	143 Nos	40	3 Nos	24	12	12	
13	Pedestal -2nd Lift Shuttering	12	143 Nos	40	3 Nos	9	4.5	4.5	
14	Pedestal -2nd Lift Concrete	13	143 Nos	40	3 Nos	3	1.5	1.5	
LEGEND								KEY	
DESCRIPTION								FONT	
Cycle Time								FONT	
Work Scope								FONT	
As Planned -Priliminary									
As Planned - Revised After 1st Delay									
Delay Due to Hard Rock, Drawing revision, Response								FONT	
Delay due to rain, dewatering - Rain & Seepage								FONT	
No delay								FONT	

LEGEND	
DESCRIPTION	KEY
Cycle Time	FONT
Work Scope	FONT
As Planned -Preliminary	
As Planned - Revised After 1st Delay	
Delay Due to Hard Rock, Drawing revision, Response	FONT
Delay due to rain, dewatering - Rain & Seepage	FONT
No delay	FONT

AS PLANNED CYCLE TIME PER DAY BEFORE DELAY 01 & AFTER DELAY 01 AND DURATION WASTAGE								
SL.NO.	ACTIVITIES	Activity Predecessor	Total Quantity	As Planned - Revised After 1st Delay		As Planned Cycle Time Before Delay 01 for 6 Footing or 30 meter Plinth Beam Per Day	Cycle time for As Revised Schedule After Delay 01 - Average Hr / day	Duration Wastage in respect to As Planned Schedule before 1st delay - 6 Footings or 30M PB per day
				Days/ Activity	No or Meter / day			
SOIL BACK FILLING								
15	Footing Backfilling	14	143 Nos	20	7 Nos	4.5	5.25	-0.75
16	Pedestal -1st Lift Backfilling	15	143 Nos	40	3 Nos	18	9	9
17	Pedestal -2nd Lift Backfilling	16	143 Nos	40	3 Nos	18	9	9
PLINTH BEAM								
18	Plinth Beam Shuttering & PCC	17	879m	40	21m	4.3	3	1.3
19	Plinth Beam Rebar work	18	879m	40	21m	13	9	4
20	Plinth Beam Shuttering	19	879m	40	21m	8.5	6	2.5
21	Plinth Beam Concrete	20	879m	40	21m	4.3	3	1.3
LEGEND								
DESCRIPTION				KEY				
Cycle Time				FONT				
Work Scope				FONT				
As Planned -Preliminary								
As Planned - Revised After 1st Delay								
Delay Due to Hard Rock, Drawing revision, Response				FONT				
Delay due to rain, dewatering - Rain & Seepage				FONT				
No delay				FONT				

4.1.11 Duration Wasted As Per Execution Vs. Actual Planned After 1st Delay

Table 4.10 : Duration Wasted As Per Execution Vs. Actual Planned After 1st Delay

DURATION WASTED AS PER EXECUTION Vs. ACTUAL PLANNED AFTER 1ST DELAY															
Sl.No.	Activities	AS PLANNED Vs. EXECUTED - WORK SCOPE PER DAY			CYCLE TIME PER DAY- AS PLANNED Vs. EXECUTED					Duration Wasted (Low to High Range)	As planned After Delay 01	Less Range	High Range	Duration Wasted before 1st delay respect to As Planned Schedule before 1st delay - 6 Footings or 30M PB per day	Activities with Labours being Ideal Due to Rain (Color Code)
		As Planned Work Scope per day- Revised After 1st Delay	As Built - Scope of Work per day	Backlog per day	1 Footing/ 30 M Plinth Beam before Day 01	6 Footing/ 30 M Plinth Beam before Day 01	High Range	Less Range							
FOOTING															
1	Footing Marking	4 Nos	1 to 2 Nos.	3 to 2 Nos.	0.25	1.5	0.75	0.5	1	0.25	0.5	1			
2	Footing Excavation	4 Nos	1 to 2 Nos.	3 to 2 Nos.	3	18	9	6	12	3	6	12			
3	Footing Soil Dressing	4 Nos	1 to 2 Nos.	3 to 2 Nos.	0.75	4.5	2.25	1.5	3	0.75	1.5	7.5			
4	Footing Shuttering & PCC	4 Nos	1 to 2 Nos.	3 to 2 Nos.	0.5	3	1.5	1	2	0.5	1	2			
5	Footing Marking & Rebar Work	4 Nos	1 to 2 Nos.	3 to 2 Nos.	3.25	19.5	9.75	6.5	13	3.25	6.5	13			
6	Footing Shuttering	4 Nos	1 to 2 Nos.	3 to 2 Nos.	2	12	6	4	8	2	4	8			
7	Footing Concrete (In 2 Layers)	4 Nos	1 to 2 Nos.	3 to 2 Nos.	2	12	6	4	8	2	4	8			
PEDESTAL															
8	Pedestal Rebar work	3 Nos	2 to 3 Nos.	1 Nos.	3	18	9	6	9	0	3	12			
9	Pedestal Starter Marking, Shuttering & Concrete	3 Nos	2 to 3 Nos.	1 Nos.	1	6	3	2	3	0	1	4			
10	Pedestal - 1st Lift Shuttering	3 Nos	1 to 3 Nos.	1 to 2 Nos.	1.5	9	4.5	3	4.5	0	1.5	6			
11	Pedestal - 1st Lift Concrete	3 Nos	1 to 3 Nos.	1 to 2 Nos.	0.5	3	1.5	1	1.5	0	0.5	2			
12	Bolt Fixing + Checking	3 Nos	1 to 3 Nos.	1 to 2 Nos.	4	24	12	8	12	0	4	16			
13	Pedestal - 2nd Lift Shuttering	3 Nos	1 to 3 Nos.	1 to 2 Nos.	1.5	9	4.5	3	4.5	0	1.5	6			
14	Pedestal - 2nd Lift Concrete	3 Nos	1 to 3 Nos.	1 to 2 Nos.	0.5	3	1.5	1	1.5	0	0.5	2			

SOIL BACK FILLING										
15	Footing Backfilling	7 Nos	7 Nos	Nil	0.75	4.5	5.25	5.25	0	0
16	Pedestal -1st Lift	3 Nos	3 Nos	Nil	3	18	9	9	0	0
17	Pedestal -2nd Lift	3 Nos	3 Nos	Nil	3	18	9	9	0	0
PUNTH BEAM										
18	PB Shuttering & PCC	21m	17 - 21 m	4 m	1	4.3	3	2.42	0	0.58
19	PB Rebar work	21m	17 - 21 m	4 m	3	13	9	7.28	0	1.72
20	PB Shuttering	21m	17 - 21 m	4 m	2	8.5	6	4.85	0	1.15
21	PB Concrete	21m	17 - 21 m	4 m	1	4.3	3	2.42	0	0.58

LEGEND	
KEY	DESCRIPTION
FONT	Cycle Time
FONT	Work Scope
	As Planned -Preliminary
	As Planned - Revised After 1st Delay
FONT	Delay Due to Hard Rock, Drawing revision, Response delay & Coordination
FONT	Delay due to rain, dewatering - Rain & Seepage Ground Water & other
FONT	No delay
FONT	Labour Available but were Ideal During Rain around 20% to 30% per day from the Available %

4.1.12 Improper Labor Availability Leading To Delay & Ideal Span (Poor Forecast)

Table 4.11: Improper Labor Availability Leading To Delay & Ideal Span (Poor Forecast)

LABOUR INVOLVED IN THE TEAM			LABOUR REQUIRED PER DAY				Unavailable/ Required %	
Sl. No.	Team	Labors Typology Involved	Sl. No.	Labour Typology	Required / Day	Available/ Day		
1	Surveyor Team	Surveyor + Helper	1	Surveyor	1	1	100%	0%
2	Soil Dressing Team	Excavator + M/C	2	Barbender	16	5	31.25%	68.75%
3	Barbender Team	Barbender + Helper	3	Helper	12	3	25%	75%
4	PCC Team	Mason + M/C	4	Mason	14	1	7.10%	92.90%
5	RCC Team	Mason + M/C	5	M/C	16	3	18.70%	81.30%
6	Shuttering Team	Carpenter + Helper	6	Carpenter	20	4	20%	80%
7	Curing Team	M/C	7	Excavator	1	1	100%	0%
8	Excavator Team	Excavator	TOTAL QUANTITY		80	18	100%	22.50%
9	Backfilling Team	M/C	Note: In the given Available %- Over 20% to 30% of Labour were Ideal during Rain per day					
LEGEND								
DESCRIPTION	KEY	KEY	KEY	DESCRIPTION				
Available as Required				Labour Available but were Ideal During Rain around 20% to 30% per day from the Available %				
Not Available as Required								

4.1.13 As Planned Vs. As Built Schedule & Lean Waste Classification

Table 4.12: As Planned Vs. As Built Schedule & Lean Waste Classification

AS PLANNED Vs. AS BUILT SCHEDULE & LEAN WASTE CLASSIFICATION- BEFORE CIVIL WORK														
Sl. No.	ACTIVITIES	As Planned Duration (Day)	As Built Schedule (Day)		Lean Waste – TIMWOODS Classification									
			Duration	Delay	T	I	M	W	O	O	D	S		
A	GEOTECHNICAL INVESTIGATION													
1	Geotechnical Investigation	10	148	367				100%						
B	SITE OFFICE AND LAND & COMPOUND WALL DEVELOPMENT – 65%													
2	Site Office and Land & Compound wall Development – 65%	184	95	374				80%				20%		
C	LAND & COMPOUND WALL DEVELOPMENT – 35%													
3	Land & Compound wall Development – 35%	196	95	364				95%				5%		
D	APPOINTMENT OF CIVIL CONTRACTOR													
4	Appointment of Civil Contractor	1	1	-										
E	BUILDING APPROVAL & SITE HANDLING													
5	Building Approval & Site Handling	-	111	111				100%						
AS PLANNED Vs. AS BUILT SCHEDULE & LEAN WASTE CLASSIFICATION- SUBSTRUCTURE CIVIL WORK														
Sl. No.	ACTIVITIES	As Planned Duration -		As Built Schedule		Lean Waste – TIMWOODS Classification								
		PEB	RCC	Duration- PEB	Delay- RCC	T	I	M	W	O	O	D	S	
F	FOOTING													
6	Footing	63	24	148	133	181	367			60%	2%		25%	13%
G	PEDESTAL													
7	Pedestal	69	26	95	100	83	374		90%				10%	
H	FILLING & COMPACTION													
8	Filling & Compaction	73	9	95	92	123	364		100%					
I	PLINTH BEAM													
9	Plinth Beam	41	20	106	90	147	367		75%			15%	10%	
OVERALL LEAN WASTAGE: Waiting – 88.125%; Over Processing-0.5%; Defects-8.75%; Skills- 3.75%														

Table 4.13: As Planned Vs. As Built Schedule & Lean Waste Classification With Delay Reason

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Sl.No.	Activities – PEB Building	As Built Work scope	T	I	M	W	O	O	D	S
A	FOOTING									
1	Footing Marking	1 to 2 Nos. / Day								
2	Footing Excavation	1 to 2 Nos. / Day								
3	Footing Soil Dressing	1 to 2 Nos. / Day								
4	Anti-Termite	1 to 2 Nos. / Day								
5	Footing Shuttering & PCC	1 to 2 Nos. / Day								
6	Footing Marking	1 to 2 Nos. / Day								
7	Footing Rebar Work – Footing & Pedestal	1 to 2 Nos. / Day								
8	Footing Shuttering	1 to 2 Nos. / Day								
9	Footing Concreting & Deshuttering	1 to 2 Nos. / Day								

Activities	As Planned	As Planned	As Built Schedule			
	Duration - PEB	Duration - RCC	Duration- PEB	Duration- RCC	Delay- PEB	Delay- RCC
Footing	63	24	148	133	181	367

REASON:

- Late Land Procurement and False Information by SIPCOT to Client
- Regarding Land Procurement
- Delay Application for Land Approval
- Drawing Coordination
- Lack of Understanding the Work Scope
- Lack of Understanding Site Requirements (Site Not Raised from NGL or Sediment)
- Lack of Understanding each Stakeholder's Requirement, Cycle time, Interdependencies and Information Flow Pattern
- Improper Coordination and Communication/ Collaboration
- Lack of Forecast of Weather and Labour during Rain
- Lack of Make Ready and Micro Level Scheduling Improper Soil / Geotechnical Analysis
- Contractor's Inability to Provide Required Manpower as Promised Earlier
- Lack of Priority to the site
- Delay of Response from Client and Design Consultants
- Waiting for Drawings and Information
- Rework of Drawings

Sl.No	Activities – PEB Building	As Built Work scope	T	I	M	W	O	O	D	S
B	PEDESTAL									
10	Pedestal Starter Marking	2 to 3 Nos. / Day								
11	Pedestal Starter Shuttering & Concrete	2 to 3 Nos. / Day								
12	Pedestal -1st Lift Shuttering	1 to 3 Nos. / Day								
13	Pedestal -1st Lift Concrete	1 to 3 Nos. / Day								
14	Bolt Fixing	1 to 3 Nos. / Day								
15	Pedestal -2nd Lift Shuttering	1 to 3 Nos. / Day								
16	Pedestal -2nd Lift Concrete	1 to 3 Nos. / Day								

Activities	As Planned	As Planned	As Built Schedule			
	Duration - PEB	Duration - RCC	Duration- PEB	Duration- RCC	Delay- PEB	Delay- RCC
Pedestal	69	26	95	100	83	374

REASON:

- Lack of Understanding Site Requirements (Site Not Raised from NGL or Site Sedimentation Planning)
- Improper Coordination and Communication/ Collaboration
- Lack of Forecast of Weather and Labour during Rain leading to labour being Ideal
- Lack of Make Ready and Micro Level Scheduling
- Contractor's Inability to Provide Required Manpower as Promised Earlier
- Lack of Priority to the site
- Improper Site Access Planning, Lack of site access.

Sl.No	Activities – PEB Building	As Built Work scope	T	I	M	W	O	O	D	S																				
C	FILLING & COMPACTION																													
17	Footing Filling & Compaction Layer	7 Nos. / Day																												
18	Pedestal- Filling & Compaction Layer 01	3 Nos. / Day																												
19	Pedestal- Filling & Compaction Layer 02	3 Nos. / Day																												
20	Pedestal- Filling & Compaction Layer 03	3 Nos. / Day																												
<table><tr><th rowspan="2">Activities</th><th>As Planned</th><th>As Planned</th><th colspan="4">As Built Schedule</th></tr><tr><th>Duration - PEB</th><th>Duration - RCC</th><th>Duration- PEB</th><th>Duration- RCC</th><th>Delay- PEB</th><th>Delay- RCC</th></tr><tr><td>Filling & Compaction</td><td>73</td><td>9</td><td>95</td><td>92</td><td>123</td><td>364</td></tr></table>											Activities	As Planned	As Planned	As Built Schedule				Duration - PEB	Duration - RCC	Duration- PEB	Duration- RCC	Delay- PEB	Delay- RCC	Filling & Compaction	73	9	95	92	123	364
Activities	As Planned	As Planned	As Built Schedule																											
	Duration - PEB	Duration - RCC	Duration- PEB	Duration- RCC	Delay- PEB	Delay- RCC																								
Filling & Compaction	73	9	95	92	123	364																								
<u>REASONS:</u> • Material Unavailability when Required • Usage of this Building 03 Site's Material to the Other • Lack of Priority to the site • Lack of Availability of Required labour as promised by Contractor																														

Sl.No	Activities – PEB Building	As Built Work scope	T	I	M	W	O	O	D	S
D	PLINTH BEAM									
21	Plinth Beam Marking	17 to 21 m / Day								
22	Plinth Beam Dressing	17 to 21 m / Day								
23	Plinth Beam Shuttering & PCC	17 to 21 m / Day								
24	Plinth Beam Marking	17 to 21 m / Day								
25	Plinth Beam Reinforcement	17 to 21 m / Day								
26	Plinth Beam Shuttering	17 to 21 m / Day								
27	Plinth Beam Concrete	17 to 21 m / Day								

Activities	As Planned Duration - PEB	As Planned Duration - RCC	As Built Schedule			
			Duration- PEB	Duration-RCC	Delay- PEB	Delay- RCC
PLINTH BEAM						
Plinth Beam	41	20	106	90	147	367

REASON:

- Lack of Understanding Site Requirements (Site Not Raised from NGL or Sediment)
- Improper Coordination and Communication/ Collaboration
- Lack of Forecast of Weather and Labour during Rain
- Lack of Make Ready and Micro Level Scheduling
- Contractor's Inability to Provide Required Manpower as Promised Earlier
- Lack of Priority to the site Lack of Site Access

4.2 RESULTS

4.2.1 Overall Calculated Lean Waste - Substructure Civil Work

Table 4.14: Overall Calculated Lean Waste & Lean Waste Classification and Challenges Head - Substructure Civil Work

OVERALL CALCULATED LEAN WASTE - SUBSTRUCTURE CIVIL WORK – QUANTITATIVE ANALYSIS				
% OF LEAN WASTAGE DUE CONVENTIONAL METHOD OF TIME MANAGEMENT				
Lean Waste Types	Wastage Occurrence in Numbers in Detail for Each Activity	% of Wastage in Respect to Number of 32 Activities	% of Wastage in Respect to Number of Other 52 Nos. of Wastage	
1. Transportation (T)	-	-	-	
2. Inventory (I)	1	3.12%	1.92%	
3. Motion (M)	-			
4. Waiting (W)	31	96.87%	59.61%	
5. Over Processing (O)	3	9.37%	5.76%	
6. Over Production (O)	-			
7. Defects (D)	6	18.75%	11.52%	
8. Skills (S)	11	34.37%	21.15%	

CLASSIFICATION HEAD - CHALLENGE & LEAN WASTE		
Sl. No	Overall Lean Waste	Challenges Head
1	Transportation	Scope Definition
2	Inventory	Project Monitoring & Control
3	Motion	Planning, Scheduling & Tracking
4	Waiting	Communication & Coordination
5	Overproduction	Design Process
6	Overprocessing	Project Needs & Site Condition
7	Defects	Resource Problem
8	Skills	Collaboration

T	 TRANSPORTATION Moving items or information	I	 INVENTORY Items or information that customer has not received	M	 MOTION Excessive movement within workspace	W	 WAITING Waiting for information or items to arrive
O	 OVERPROCESSING Doing more work than necessary	O	 OVERPRODUCTION Doing work before it is needed	D	 DEFECTS Mistakes and errors that need to be reworked	S	 SKILLS Not using workers to fullest of abilities

4.2.2 Delay Reasons, Challenges & Lean Waste and Responsibility

Table 4.15: Delay Reasons, Challenges & Lean Waste and Responsibility

DELAY REASONS, CHALLENGES & LEAN WASTE CATEGORY AND RESPONSIBILITY				
NO	DELAY REASONS	CHALLENGES	LEAN WASTE	RESPONSIBILITY
1	Change orders by owner during construction (Variations) -due to mezzanine relocation	Scope definition, Collaboration, Communication & Coordination	Once production waiting defects	Owner
2	Rework in footing layout due to misalignment of footing sitting in architectural and structural drawing	Design process, Communications & Coordination, Collaboration, Information Flow	Defects Waiting	Architect and Structural Consultant
3	Ineffective coordination between architect structural consultant and also with other design consultants	Communications & Coordination, Collaboration, Information Flow	Defects Waiting	Architect and Structural Consultant & Other Design Consultant
4	Lack of coordination between structural consultant and client contractors	Communications & Coordination, Collaboration, Information Flow	Defects Waiting	Structural Consultant & Civil Contractors
5	Lack of understanding contractors structural requirement by structural lay out: Revision of footing, pedestal layouts & Detailing as per contractor requirement of similar shuttering	Scope definition, Collaboration, Communication & Coordination	Defects Waiting	Structural Consultant & Civil Contractors
DELAY REASONS, CHALLENGES & LEAN WASTE CATEGORY AND RESPONSIBILITY				
NO	DELAY REASONS	CHALLENGES	LEAN WASTE	RESPONSIBILITY
6	Delay in delivery of drawings - GFC Drawings after revision	Communications & Coordination, Collaboration Information	Waiting	Design Consultants & PMC
7	Date participation or consultation of Vastu consultant after construction of planned footing works	Planning, Scheduling & Tracking, Prerequisite, Scope Definition, Design Process, Collaboration	Defects Waiting	Force Majere
8	Uncertainties in site a) Rain (weather) b)Hard rock required to extracted for foundation	Prerequisite, Project Need & Site Condition, Information	Defects Waiting	SIPCOT Owner
9	Delayed land approval for construction-DC land	Prerequisite, Project Need & Site Condition, Information	Waiting	SIPCOT Owner
10	Delayed in procurement of land by land owner (SIPCOT) Not in right sequence	Prerequisite, Project Need & Site Condition, Information	Waiting	SIPCOT Owner

DELAY REASONS, CHALLENGES & LEAN WASTE CATEGORY AND RESPONSIBILITY				
NO	DELAY REASONS	CHALLENGES	LEAN WASTE	RESPONSIBILITY
11	Lack of priority to the site for construction leading to : A)Lack of availability of labour (25 out of 80 numbers) B) Lack of availability of construction equipments - Dewatering pumps C)Use of building materials for other buildings leading to delay of construction process. eg. Excavated top soil from Building 3 used for other sites filling; leading to waiting for soil for filling process when required . D) Lack of skilled labour E)Due to lack of priority to site , other surrounding site were raised from NGL, while Building 3 site became lowest in level leading to accumulation of rain water from other site , perhaps leading to additional work of dewatering . Main water in addition to dewater ground water seepage and rework.	Resource, Project Need & Site Condition, Project Planning, Scheduling & Tracking, Monitor and Control, Prerequisite	Waiting Inventory, Defects, Skills	Contractor

DELAY REASONS, CHALLENGES & LEAN WASTE CATEGORY AND RESPONSIBILITY				
NO	DELAY REASONS	CHALLENGES	LEAN WASTE	RESPONSIBILITY
11	Labour under utilized during raining time since not forecasted earlier	Resource, Prerequisite	Skill	Force Majeure PMC
12	PEB work started at PEB contractor work station & Steel rod for rebar work available at site prior to the RCC construction started at the building 3 site leading to long duration of inventory storage.	Resource, Prerequisite, Communications & Coordination, Collaboration	Inventory	Owner PMC
13	Geo technical investigation Equipment unavailable compared to required quantity leading to delay	Resource	Waiting	Geo consultant
14	Samy builders : Land development & Compound wall -35% a) Low productivityleading site delayed site handling	Planning, Scheduling & Tracking(productivity mapping), Communication & Coordination, Collaboration, Monitoring & Controlling (Wrong selection of contractors)	Defects Waiting	Samy contractors
15	Poor communication & coordination between project participants-during scheduling,design, construction process	Scope Defination, Collaboration, Communication & Coordination, Project Need & Site Condition	Defects Waiting	All participants
16	Lack of early involvement of contractors during design & scheduling stage	Collaboration, Planning, Scheduling & Tracking, Design process, Scope defination	Defects Waiting	Design Consultants, Contractors, Owner

DELAY REASONS, CHALLENGES & LEAN WASTE CATEGORY AND RESPONSIBILITY				
NO	DELAY REASONS	CHALLENGES	LEAN WASTE	RESPONSIBILITY
17	Contractors not aware of other contractors work flow requirements, Prerequisite and cycle time and work interdependencies leading to delay	Collaboration, Planning, Scheduling & Tracking, Design process, Scope definition	Defects Waiting	Contractors PMC
18	Lack of inputs and responses in timely manner from client side , difficult to get approval and understand user requirements	Collaboration, Planning, Scheduling & Tracking, Design process, Scope definition	Defects Waiting	Owner
19	Preliminary drawings were only available before construction started. Detailed GFC drawings were available only before that activity started.	Information, Planning, Scheduling & Tracking, Design process, Scope Definition, Project Need & Site Condition, Monitoring & Controlling	Waiting	Contractors PMC
20	Inadequate details in architecture layout.	Design process, Information	Defects Waiting	Architect
21	Lack of coordination in Drawings from different design consultants	Design process, Communications & Coordination, Collaboration, Information Flow, Scope Definition	Defects Waiting	Design Consultants
22	Unaware of land ownership & land approval by client - SIPCOT politics with land owners , insufficient and improper information provided to the client	Communications & Coordination, Collaboration, Information Flow	Waiting	SIPCOT Owner
DELAY REASONS, CHALLENGES & LEAN WASTE CATEGORY AND RESPONSIBILITY				
NO	DELAY REASONS	CHALLENGES	LEAN WASTE	RESPONSIBILITY
23	SHIRISTI: A) Inadequate planning of work B) Poor quality of work C) Lack of effective response to the delay D) No response to PMC delay intimation from client & contractor side due to friendship between contractors and client and less priority to site building 3 E) Poor productivity	Planning, Scheduling & Tracking, Monitoring , Communication and Coordination, Information, Prerequisite, Collaboration	Waiting	Shiristi
24	Building 3 site was used as access to other surrounding site , surrounding construction became constraint to Building 3 was not planned earlier	Project Need & Site Condition, Pre Requisite , Planning	Waiting	Owner PMC Contractors
25	Dewatering has led to additional cost due to which availability of dewatering pump was less than what is required	Project Need & Site Condition, Pre Requisite , Planning, Scheduling & Tracking, Resource	Waiting, No Value Generation	Force Majere, PMC, Prior Forecast
26	Macro level planning didn't take in to consideration of micro level detailed planning interdependencies, constraint, Pre requisite , information, resource. check(information prior work to be completed , drawings, specs, work scope) before work begin.	Collaboration, Planning Scheduling & Tracking, Monitoring & Control, Prerequisite, Design process, Information, Project need & Site Condition, Scope Definition	Defects Waiting	PMC (PM method)

DELAY REASONS, CHALLENGES & LEAN WASTE CATEGORY AND RESPONSIBILITY				
NO	DELAY REASONS	CHALLENGES	LEAN WASTE	RESPONSIBILITY
27	Site access restriction during rain - low lying area compared to other sites.	Project need need of Site condition, Pre requisite	Waiting	Contractors PMC Owner
28	COVID-19 lock down	Uncertainty	Defects Waiting	Force Majere
29	Ineffective involvement of Vastu consultant during design stage	Scope information Communication Collaboration Design projects Schedule	Defects Waiting	Owner Architect Vastu consultant
30	Lack of structured flow of information	Communications & Coorditanation Collaboration Information	Delay Waiting	All the participants
31	Lack of proactive decision making	Communications & Coorditanation, Collaboration Information, Planning schedule	Waiting	Owner PMC (PM method)
32	Unsynchronised process	Scope information Communication Collaboration Design projects Schedule, Prerequisite, Resource, Site Condition, Project Monitor and Control	Waiting	Owner Contractor PMC (PM Method) Design consultant

OVERALL CHALLENGE HEAD & LEAN WASTE FACED HERE		
Sl. No	Overall Lean Waste	Challenges Head
1	Defects	Scope Definition
2	Waiting	Project Monitoring & Control
3	Inventory	Planning, Scheduling & Tracking
4	Overproduction	Communication & Coordination
5	Skills	Design Process
6		Project Needs & Site Condition
7		Resource Problem
8		Collaboration

4.2.3 Overall Challenges & Lean Waste and Project Aspiration

Table 4.16: Overall Challenges & Lean Waste and Project Aspiration

	PROJECT ASPIRATION
1	Early Selection & Involvement of project participants
2	Collaboration - Online / Offline (Colocation)
3	Value Generation - Eliminate Rework
4	Continuous & Standardized Information flow
5	Micro level Scheduling & taking into account of Variables & Constraints at each micro levels
6	Commitment based collaborative planning - Increased Accountability, Reliability and better Understanding Scope, Interdependencies, Cycletime
7	Proactive Decision Making & Constraint Analysis prior it occurs or prior activity being executed and Consideration of Prerequisite (Tasks & Weather); Informations (Drawings, Work Methodology, Guidelines, Specs, etc) & Resources (Labour, Machine, Equipment & Machinery)
8	Continuous learning
9	Collaborative Problem Solving Approach
10	Increased Communication & Coordination between Participants
11	Increased Productivity & Continuous tracking and productivity analysis (PPC - Percentage Project Completion)
12	Proper Work Sequencing / Work flow management
13	Cross Cluster formation for collaborative design work and enhance coordination in layouts and share ideas to avoid revisions and rework
14	Early response / Timely Information flow and effective participation from Client and other project participants
15	Reduce change request by client & other participants
16	Planning based on available resources and to be predetermined by contractor and equal priority to all buildings
17	Importance to Interdependencies
18	Transparency between Participants - Information flow

CHAPTER 5 SUMMARY AND CONCLUSION

5.1 RECOMMENDATIONS – LEAN BASED SOLUTION (LAST PLANNER SYSTEM)

5.1.1 Lean Based Solution and Its Purpose

Table 5.1: Lean Based Solution and Its Purpose

SOLUTION & ITS PURPOSE		
	Solution	Purpose
1	Early & Continuous Involvement of all project participants - Collaboration - Big Room	Planning, Scheduling & Tracking; Problem Solving, Communication & Coordination and Design Process
2	Cross Cluster Formation	Design Process
3	Effective Involvement of Client throughout Project Lifecycle	Scope Definition, Planning, Scheduling & Tracking; Problem Solving, Communication & Coordination, Design Process and Continuous flow
4	User/ Project Requirement Documentation	Scope Definition
5	Planning with Integration of Design & Construction Stage	Planning, Scheduling & Tracking and Continuous flow
6	A3 Design Thinking	Design Process, Scope Definition, Planning, Scheduling & Tracking
7	Equal Importance to : Transformation, Value Generation & Continuous Information Flow at each stage of activity	Design Process, Alignment to Scope, Planning, Scheduling & Tracking and Continuous flow
8	Creating Standard Guidelines / Procedures to be followed by Workers	Continuous flow & Alignment to Scope
9	Choosing By Advantages	Design Process & Decision Making tool
10	Last Planner System	
a	Master Schedule	Planning & Scheduling
b	Collaborative Programming + ADM Model (Make Ready - Prerequisite, Information & Resources)	Planning, Scheduling & Tracking, Continuous flow, Problem Solving, Constraints Analysis, Resource Planning and Constraints Removal
c	Make Ready Planning	
d	Production Planning / Weekly Work Plan	
e	Production Management	
f	Measurement, Learning & Continuous Improvement (Percentage Project Completion (PPC) & PDCA)	
g	First Run Studies - Using Root Cause Analysis (A3 Problem Solver - PDCA)	
11	Visualisation	Planning, Scheduling & Tracking, Constraint Log, Safety, Resources and Motivation

REQUIREMENT FROM PMC

- Contractor need to share their weekly Work Plan (It should Contain weekly Planned activities with Manpower and Material).
 - Daily Labour Report and Daily Progress Report should be sent Before next day work begins to PMC.
 - Manpower (Highlighted Manpower is needed)
-
- Weekly Review Meeting with Planned Activities vs Achieved Activities with Quantity (PPC)
 - All Material & Other Approvals should be discussed earlier with PMC (Not in Progress Meeting)
 - Contractor should be Transparent in Site Issues.
-
- Lean Tool will be useful for Collaborative Meeting to identify issues with All the stakeholders (Client, PMC, Contractors, Design Consultants, Vendors) to increase the Productivity of the Project.
 - Use of Last Planner System (LPS) For Scheduling – That employs Proactive Constraint Analysis and removal and Macro & Microlevel Scheduling with Makeready with Reliable Commitment based Collaborative Planning & Scheduling
 - A3 Problem Solver/ Design Thinking & FRS that employs PDCA Approach for Root Cause Analysis & Collaborative Problem Solving Approach.
 - Visualization aids Motivation, Tracking, Constraint Log & Maintain Schedule on Track

Fig 5.1 Lean Based Solution as a Requirement from PMC Team

5.1.2 Work Process (Conventional Vs. Implemented Vs. As Per Lean)

Table 5.2: Work Process (Conventional Vs. Implemented Vs. As Per Lean) - From Design to Footing Substructure Civil Work

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE				
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN	
INITIATION TO FEASIBILITY STAGE				
1	Project Initiation	Project Initiation	Project Initiation	Project Initiation
2	Project Feasibility Analysis	Project Feasibility Analysis	Project Feasibility Analysis & Land Procurement	Project Feasibility Analysis & Land Procurement
3	Land Procurement	Appointment of Tata Consultancy Engineering By Client	Appointment of Tata Consultancy Engineering By Client	Appointment of Tata Consultancy Engineering By Client
4	Appointment of PMC	Appointment of EPMCR, Chennai by Tata Consultancy as PMC Outsourcing	Appointment of EPMCR, Chennai by Tata Consultancy as PMC Outsourcing	Appointment of EPMCR, Chennai by Tata Consultancy as PMC Outsourcing
5	Kick off Meeting	Kick off Meeting	Kick off Meeting	Kick off Meeting
6	User Requirement Documentation	User Requirement Documentation	User Requirement Documentation	User Requirement Documentation
7	Preparation of Preliminary Master Schedule - Project Planner	Preparation of Preliminary Master Schedule - Project Planner	Preparation of Preliminary Master Schedule - Project Planner	Preparation of Preliminary Master Schedule - Project Planner
8	Client Approval & PMC Approval	Client Approval & PMC Approval	Client Approval & PMC Approval	Client Approval & PMC Approval
DESIGN STAGE				
9	Appointment of Structural Consultant	Appointment of Geotechnical Investigator by TCE	Appointment of Geotechnical Investigator by TCE	Appointment of Geotechnical Investigator by TCE
10	Appointment of Geotechnical Investigator by Structural Consultant	Geotechnical Analysis	Geotechnical Analysis	Appointment of MEP Consultant by TCE
11	Geotechnical Analysis	Geotechnical Report	Geotechnical Report	Appointment of Costing Team
12	Geotechnical Report	Architect Appointment by Tata Consultancy as PMC Outsourcing	Architect Appointment by Tata Consultancy as PMC Outsourcing	Appointment of Vastu Consultant
13	Architect Appointment	User Requirement Documentation	User Requirement Documentation	Kick off Meeting by PMC with all the appointed Design Consultants and Client Team - Big Room (Collaborative Meeting / Colocation- online or offline mode)
14	User Requirement Documentation	Client Approval & PMC Approval	Client Approval & PMC Approval	Big Room - Project Introduction; Stakeholder Introduction; Scope Definition; User Requirement Documentation; Project Need & Site Condition
15	Client Approval & PMC Approval	Collecting Master Schedule from Architecture Team by PMC Team - Project Planner	Collecting Master Schedule from Architecture Team by PMC Team - Project Planner	Big Room - Master Schedule Distributed and Analyse

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
15	Collecting Master Schedule from Architecture Team by PMC Team - Project Planner	Revision of Preliminary Master Schedule - Project Planner	Big Room -Introduction on Lean Concept, Principle, Last Planner System & Last Planner System Procedure to Project team and Training on Method of Implementation of Last Planner System & Project Objectives linkage with LPS
16	Revision of Preliminary Master Schedule - Project Planner	Client Approval & PMC Approval	Big Room - Collaborative Preparation of : Work Break down Structure; Work out Interdependencies, Cycle time and work flow pattern for commitment based planning and structured Information flow
17	Client Approval & PMC Approval	Zoning & Spatial Analysis and Report	Big Room - Constraint Analysis through First Run Studies (A3 Problem Solver- PDCA); Reverse Phase Planning & Schedule and Further Compression
18	Zoning & Spatial Analysis and Report	Conceptual Layout & Dimentions	Distribution of Reverse Phase Schedule to all the design Consultants & Visualisation at common locations
19	Conceptual Layout & Dimentions	Preliminary Costing - Class D	Big Room - Preparation of Six Weeks Look Ahead Schedule (Occurs Every 2 weeks / 6 weeks) by PMC Project Planner - Micro level 2 to 6 week look ahead schedule with interaction with design Consultants to create constraints log for activities with lead time, Constraint Analysis and proactive decision making to remove constraints through A3 Problem Solver; Create lookahead window for make ready (Prerequisites, Resources, Information Check list) and Assign resources.

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
20	Preliminary Costing - Class D	Client Approval & PMC Approval	Big Room - Weekly Work Plan (Occurs every Weekly): Each Trade submits their own upcoming week's schedule to PMC & Client. It includes work to be done next week, Reason for delay , Root cause Analysis and solution through FRS - A3 Problem Solver
21	Client Approval & PMC Approval	Schematic Architecture Layout	Appointment of Geotechnical Investigator by TCE
22	Appointment of Vastu Consultant	Preliminary Costing - Class C	Geotechnical Analysis
23	Vastu Consultation	Client Approval & PMC Approval	Geotechnical Report
24	Schematic Architecture Layout	Detailed Architecture Layouts & Detailing - 50 %	Cross Cluster Group Formation & Meetings- For Design Process
25	Preliminary Costing - Class C	Material Analysis & Supplier / Vendor Analysis	Daily Meeting - Work to be done, Daily Project Report, Work Progress & Problem Solver - PDCA
26	Client Approval & PMC Approval	Preliminary Costing - Class B	A3 Design Thinking
27	Detailed Architecture Layouts & Detailing - 50	Client Approval & PMC Approval	Zoning & Spatial Analysis and Report
28	Material Analysis & Supplier / Vendor Analysis	Structural Consultant - Structural Design	Vastu Consultation
29	Preliminary Costing - Class B	Analysis of URD, Architectural Layouts & Detailing	Architectural Conceptual Layout & Dimentions
30	Client Approval & PMC Approval	Load Analysis & Schematic Structural Layout	Load Analysis & Conceptual Structural Layout
31	Land Approval Submission to CMDA	Client Approval & PMC Approval	Preliminary Costing - Class D - Costing Team
32	Structural Consultant - Structural Design	Collecting Master Schedule from Structural Team by PMC Team	Cross Cluster Meeting + PPC (Daily, Weekly, Monthly, Trade, overall Project)
33	Analysis of URD, Architectural Layouts & Detailing	Revision of Preliminary Master Schedule - Project Planner	Client Approval & PMC Approval
34	Load Analysis & Schematic Structural Layout	Client Approval & PMC Approval	Schematic Architecture Layout
35	Client Approval & PMC Approval	Preliminary Structural Layouts & Detailing	Load Analysis & Schematic Structural Layout

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
36	Collecting Master Schedule from Structural Team by PMC Team	Client Approval & PMC Approval	Preparation of load Analysis & Spatial Requirements and zoning in site plan
37	Revision of Preliminary Master Schedule - Project Planner	Preliminary Structural Layouts to Architecture Team	Preparation of Schematic MEP Drawings
38	Client Approval & PMC Approval	Approval from Architecture Team - Coordination of drawings (Architecture & Structural Drawing)	Material Study, Supplier & Vendor Analysis
39	Preliminary Structural Layouts & Detailing	Appointment of Costing Team	Preliminary Specification; DOM, Unit Rate Analysis & Class D BOQ Preparation
40	Client Approval & PMC Approval	URD & Drawings Analysis, Material Study, Supplier & Vendor Analysis	Cross Cluster Meeting + PPC (Daily, Weekly, Monthly, Trade, overall Project)
41	Preliminary Structural Layouts to Architecture Team	Preliminary Specification; DOM, Unit Rate Analysis & Class D BOQ Preparation	Client Approval & PMC Approval
42	Approval from Architecture Team - Coordination of drawings (Architecture & Appointment of Costing Team	Client Approval & PMC Approval	Detailed Architecture Layouts & Detailing - 50 %
43	Appointment of Costing Team	Appointment of MEP Consultant by TCE	Land Approval Submission to CMDA
44	URD & Drawings Analysis, Material Study, Supplier & Vendor Analysis	Analysis of URD, Architectural and Structural Layouts & Detailing	Preliminary Structural Layouts & Detailing
45	Preliminary Specification; DOM, Unit Rate Analysis & Class D BOQ Preparation	Preparation of load Analysis & Spatial Requirements and zoning in site plan	Preparation of MEP Preliminary Layouts
46	Client Approval & PMC Approval	Preparation of Schematic MEP Drawings	Technical Specification; DOM, Unit Rate Analysis & Class C BOQ Preparation
47	Appointment of MEP Consultant	Client Approval & PMC Approval	Cross Cluster Meeting + PPC (Daily, Weekly, Monthly, Trade, overall Project)
48	Analysis of URD, Architectural and Structural Layouts & Detailing	Collecting Master Schedule from MEP Team by PMC Team	Client Approval & PMC Approval
49	Preparation of load Analysis & Spatial Requirements and zoning in site plan	Revision of Preliminary Master Schedule - Project Planner	Detailed MEP Drawings, Site Plan & Detailing (50%) Preparation
50	Preparation of Schematic MEP Drawings	Client Approval & PMC Approval	Preparation of Detailed Structural Layouts & Detailings (50%) - Structural Team
51	Client Approval & PMC Approval	Preparation of MEP Preliminary Layouts	Coordination Drawings
52	Collecting Master Schedule from MEP Team by PMC Team	Client Approval & PMC Approval	Cross Cluster Meeting + PPC (Daily, Weekly, Monthly, Trade, overall Project)
WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
53	Revision of Preliminary Master Schedule - Project Planner	Preliminary MEP Drawings to Architecture & Structural Team for Preparation of Coordination Drawing	Client Approval & PMC Approval
54	Client Approval & PMC Approval	Detailed MEP Drawings, Site Plan & Detailing (50%) Preparation	Detailed Architecture Layouts & Detailing - 75%
55	Preparation of MEP Preliminary Layouts	Client Approval & PMC Approval	Preparation of Detailed Structural Layouts & Detailings (75%) - Structural Team
56	Client Approval & PMC Approval	Detailed MEP Drawings, Site Plan & Detailing (50%) to Architecture & Structural Team for Coordination	Preparation of MEP Detailed Layouts, Site Plan & Detailings - 75 %
57	Preliminary MEP Drawings to Architecture & Structural Team for Preparation of	Detailed Architecture Layouts & Detailing - 75%	Coordination Drawings
58	Detailed MEP Drawings, Site Plan & Detailing (50%) Preparation	Revised Preliminary Costing - Class B	Technical Specification; DOM, Unit Rate Analysis & Class B BOQ Preparation
59	Client Approval & PMC Approval	Client Approval & PMC Approval	Cross Cluster Meeting + PPC (Daily, Weekly, Monthly, Trade, overall Project)
60	Detailed MEP Drawings, Site Plan & Detailing (50%) to Architecture & Structural Team for Coordination	Technical Specification; DOM, Unit Rate Analysis & Class C BOQ Preparation	Client Approval & PMC Approval
61	Detailed Architecture Layouts & Detailing - 75%	Client Approval & PMC Approval	Detailed Architecture Layouts & Detailing - 100%
62	Revised Preliminary Costing - Class B	Technical Specification; DOM, Unit Rate Analysis & Class B BOQ Preparation	Preparation of Detailed Structural Layouts & Detailings (100%) - Structural Team
63	Client Approval & PMC Approval	Client Approval & PMC Approval	Preparation of MEP Detailed Layouts, Site Plan & Detailings - 100 %
64	Technical Specification; DOM, Unit Rate Analysis & Class C BOQ Preparation	Preparation of Detailed Structural Layouts & Detailings (75%) - Structural Team	Coordination Drawings
65	Client Approval & PMC Approval	Client Approval & PMC Approval	Technical Specification; DOM, Unit Rate Analysis & Class B BOQ Preparation
66	Technical Specification; DOM, Unit Rate Analysis & Class B BOQ Preparation	Preparation of MEP Detailed Layouts, Site Plan & Detailings - 75 %	Cross Cluster Meeting + PPC (Daily, Weekly, Monthly, Trade, overall Project)
67	Client Approval & PMC Approval	Client Approval & PMC Approval	Client Approval & PMC Approval

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE				
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN	
68	Preparation of Detailed Structural Layouts & Detailings (75%) - Structural Team	Technical Specification; DOM, Unit Rate Analysis & Class A BOQ Preparation	Good For Construction Drawings - Architecture Team	
69	Client Approval & PMC Approval	Client Approval & PMC Approval	Good For Construction Drawings - Structure Team	
70	Preparation of MEP Detailed Layouts, Site Plan & Detailings - 75 %	Detailed Architecture Layouts & Detailing - 100%	Good For Construction Drawings - MEP Team	
71	Client Approval & PMC Approval	Revised Preliminary Costing - Class A	Cross Cluster Meeting + PPC (Daily, Weekly, Monthly, Trade, overall Project)	
72	Technical Specification; DOM, Unit Rate Analysis & Class A BOQ Preparation	Client Approval & PMC Approval	Client Approval & PMC Approval	
73	Client Approval & PMC Approval	Preparation of Detailed Structural Layouts & Detailings (100%) - Structural Team		
74	Detailed Architecture Layouts & Detailing - 100 %	Client Approval & PMC Approval		
75	Revised Preliminary Costing - Class A	Preparation of MEP Detailed Layouts, Site Plan & Detailings - 100 %		
76	Client Approval & PMC Approval	Client Approval & PMC Approval		
77	Preparation of Detailed Structural Layouts & Detailings (100%) - Structural Team	Good For Construction Drawings - Architecture Team		
78	Client Approval & PMC Approval	Good For Construction Drawings - Structure Team		
79	Preparation of MEP Detailed Layouts, Site Plan & Detailings - 100%	Good For Construction Drawings - MEP Team		
80	Client Approval & PMC Approval			
81	Good For Construction Drawings - Architecture			
82	Good For Construction Drawings - Structure			
83	Good For Construction Drawings - MEP Team			
84	Submission for Approval from Fire Dept.			
85	CONTRACTING & TENDERING PROCESS			
	CONTRACTOR APPOINTMENT & SHOP DRAWING PREPARATION			
86	Appointment of Civil Contractor	Appointment of Civil Contractor (Arun Excelllo)	Appointment of Civil Contractor (Arun Excelllo)	
87	Preparation on Civil Shop Drawing by Structural Consultant & Civil Contractor	Land Procurement Process Initiation	Appointment of PEB Contractor	
88	Client Approval & PMC Approval	Land Approval Submission to CMDA	Appointment of Plumbing & Fire fighting Contractor	
89	Release of Civil Shop Drawings	Appointment of PEB Contractor	Appointment of STP & ETP Contractor	
90	Appointment of PEB Contractor	Appointment of Plumbing & Fire fighting Contractor	Appointment of Electrical Contractor	
91	Preparation on PEB Shop Drawing by Structural Consultant & PEB Contractor	Appointment of STP & ETP Contractor	Kick off Meeting by PMC with all the appointed Design Consultants, Contractors, Foreman and Client Team - Big Room (Collaborative Meeting / Colocation- online or offline mode)	
92	Client Approval & PMC Approval	Appointment of Electrical Contractor	Big Room - Project Introduction; Stakeholder Introduction; Scope Definition; User Requirement Documentation; Project Need & Site Condition	
93	Release of PEB Shop Drawings	Collection of all the GFC & Distribute 3 sets to the Individual Contractor respect to Work package of all the shop drawings - Drawing Register by TCE & PMC Team	Big Room (Design Consultants, Contractors, Foreman and Client) - Master Schedule Distributed and Analyse	
94	Appointment of Plumbing & Fire fighting Contractor	Material & Labour Planning	Big Room: Pilot Study (PMC, Contractor & Foreman) - Introduction on Lean Concept, Principle, Last Planner System & Last Planner System Procedure to Project team and Training on Method of Implementation of Last Planner System & Project Objectives linkage with LPS	
95	Preparation on Plumbing & Fire fighting Shop Drawing by MEP Consultant and Plumbing & Fire fighting Contractor	Material & Labour Planning based Construction Master Schedule Revision & Resource Allocation	Big Room - Collaborative (PMC, Client, Contractors, Foreman & Design Consultant) Preparation of : Work Break down Structure; Work out Interdependencies, Cycle time and work flow pattern for commitment based planning and structured information flow	

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
96	Client Approval & PMC Approval		Big Room - (PMC, Client, Contractor, Foreman & Design Consultant) Constraint Analysis through First Run Studies (A3 Problem Solver- PDCA); Reverse Phase Planning & Schedule and Further Compression
97	Release of Plumbing & Fire fighting Shop Drawings		Distribution of Reverse Phase Schedule to all the Contractor, Foreman, Client & Design Consultants & Visualisation at common locations
98	Appointment of STP & ETP Contractor		Big Room - Preparation of Six Weeks Look Ahead Schedule (Occurs Every 2 weeks / 6 weeks) by PMC Project Planner - Micro level 2 to 6 week look ahead schedule in interaction with Contractor, Foreman, Client & Design Consultants to create constraints log for activities with lead time, Constraint Analysis and proactive decision making to remove constraints through A3 Problem Solver; Create lookahead window for make ready (Prerequisites, Resources, Information Check list) and Assign resources.
99	Preparation on STP & ETP Shop Drawing by MEP Consultant and STP & ETP Contractor		Big Room - Weekly Work Plan (Occurs every Weekly- PMC, Client Team, Contractors & Design Consultants): Each Trade submits their own upcoming week's schedule to PMC & Client. It includes work to be done next week, Reason for delay, Root cause Analysis and solution through FRS - A3 Problem Solver
100	Client Approval & PMC Approval		Daily Meeting (PMC, Client Team, Contractors & Design Consultants) - Work to be done, Daily Project Report, Work Progress & Problem Solver PDCA

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
101	Release of STP & ETP Shop Drawings		Preparation on Civil Shop Drawing by Structural Consultant & Civil Contractor
102	Appointment of Electrical Contractor		Client Approval & PMC Approval
103	Preparation on Electrical Shop Drawing by MEP Consultant and Electrical Contractor		Release of Civil Shop Drawings
104	Client Approval & PMC Approval		Preparation on PEB Shop Drawing by Structural Consultant & PEB Contractor
105	Release of Electrical Shop Drawings		Client Approval & PMC Approval
106	Collection of all the shop drawings & Ensure Availability of all the shop drawings - Drawing Register		Release of PEB Shop Drawings
107	Material & Labour Planning		Preparation on Plumbing & Fire fighting Shop Drawing by MEP Consultant and Plumbing & Fire fighting Contractor
108	Material & Labour Planning based Construction Master Schedule Revision & Resource Allocation		Client Approval & PMC Approval
109			Release of Plumbing & Fire fighting Shop Drawings
110			Preparation on STP & ETP Shop Drawing by MEP Consultant and STP & ETP Contractor
111			Client Approval & PMC Approval
112			Release of STP & ETP Shop Drawings
113			Preparation on Electrical Shop Drawing by MEP Consultant and Electrical Contractor
114			Client Approval & PMC Approval
115			Release of Electrical Shop Drawings
116			Collection of all the shop drawings & Ensure Availability of all the shop drawings - Drawing Register

SITE DEVELOPMENT WORKS			
117	Site Development & Compound wall Contractor Appointment	Site Development & Compound wall Contractor Appointment - Shrusti Contractor	Big Room- 2 Weeks Look Ahead Meeting (PMC, Client Team, Site Development Contractor, Civil Contractor) - to create constraints log for activities with lead time, Constraint Analysis and proactive decision making to remove constraints through A3 Problem Solver ; Create lookahead window for make ready (Prerequisites, Resources, Information Check list) and Assign resources.
118	Site Clearance	Site Clearance & Compound wall development Start	Big Room : ADM Model - Constraints Analysis and removal before Activity Starts for continuous flow, Includes Prerequisites (Tasks, Weather); Directives / Information (Drawings, Instructions, Contract, RFIs, Method Statement) & Resources (Labours, Plant, Space, Materials)
119	Site Compound wall development	Site Office Development	Big Room - Weekly Work Plan (Occurs every Weekly) : Site Development Contractor submits his own upcoming week's schedule to PMC & Client. It includes work to be done next week, Reason for delay , Root cause Analysis and solution through FRS - A3 Problem Solver
120	Site Office Development	Site Clearance & Compound wall development - 65% only completed	Daily Meeting (PMC, Client Team, Site Development Contractor)- Work to be done, Daily Project Report, Work Progress & Problem Solver - PDCA
121	Site Handling		Daily Huddle Meeting (PMC, Site Development Contractor & Labours) - Work to be done, Daily Project Report, Work Progress & Problem Solver - PDCA
122		Site Development & Compound wall Contractor Appointment - Samy Builders	Site Development & Compound wall Contractor Appointment

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
123		Compound wall development - 35% Remaining to Procure Land & speed up land approval process	Site Clearance
124		Land Procured	Site Compound wall development
125		Land Approved by CMDA	Site Office Development
126		Site Clearance - 35% Remaining	Site Handling
127		Site Handling	
CIVIL SUBSTRUCTURE WORKS			
128	Civil Work Initiation	Civil Work Initiation	Civil Work Initiation
129	Shop Drawing for Civil Work - Release	FOOTING ACTIVITIES	Big Room- 2 Weeks Look Ahead Meeting (PMC, Client Team, Civil Contractor, Structural Consultant & Foreman) - to create constraints log for activities with lead time, Constraint Analysis and proactive decision making to remove constraints through A3 Problem Solver ; Create lookahead window for make ready (Prerequisites, Resources, Information Check list) and Assign resources.
130	Material, Equipment & Labour Procurement - Civil Package	Release of GFC for Civil Work (for Footing Works) to prepare shop drawings by Civil Contractor & Structural Consultant	Big Room : ADM Model - Constraints Analysis and removal before Activity Starts for continuous flow, Includes Prerequisites (Tasks, Weather); Directives / Information (Drawings, Instructions, Contract, RFIs, Method Statement) & Resources (Labours, Plant, Space, Materials)
131	FOOTING ACTIVITIES	Misalignment in footing location in architecture layout Vs. Structural Layout	Big Room - Weekly Work Plan (Occurs every Weekly) : Civil Contractor submits his own upcoming week's schedule to PMC & Client. It includes work to be done next week, Reason for delay , Root cause Analysis and solution through FRS - A3 Problem Solver

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE			
STEPS	CONVENTIONAL	EXECUTED HERE IN BUILDING 03	AS PER LEAN
132	PEDESTAL ACTIVITIES	Request Submitted & Consulted Client Side Structural Consultant and PMC Team	Daily Meeting (PMC, Client Team, Civil Contractor, Structural Consultant) - Work to be done, Daily Project Report, Work Progress & Problem Solver - PDCA
133	SOIL FILLING ACTIVITIES	Revision of GFC Structural in respect to Architecture layout with proper Coordination & Alignment of footing	Daily Huddle Meeting (PMC, Civil Contractor, Foreman & Labours) - Work to be done, Daily Project Report, Work Progress & Problem Solver PDCA
134	PLINTH BEAM ACTIVITIES	Client Approval & PMC Approval	Shop Drawing for Civil Work - Release
135	Work Quality, Specification, Measurement and Alignment Check, Daily Progress Meets, Weekly Progress, Monthly Report & Problem Solving - PMC Team; Client Team & Civil Contractor Team after each Activity Completion	Contractor's requirement for similar footing size where ever possible to reduce shuttering wastage and cost spent on shuttering reduction	Material, Equipment & Labour Procurement - Civil Package
136	CIVIL SUPERSTRUCTURE WORKS TO BEGIN	Request Submitted & Consulted Client Side Structural Consultant and PMC Team	FOOTING ACTIVITIES
137		Revision of GFC Structural drawings with similar footing sizes where ever possible	PEDESTAL ACTIVITIES - SITE EXECUTION
138		Client Approval & PMC Approval	SOIL FILLING ACTIVITIES
139		Preparation on Civil Shop Drawings for footing works by Structural Consultant (TCE) & Civil Contractor (Arun Excelllo)- Footing Activities	PLINTH BEAM ACTIVITIES
140		Client Approval & PMC Approval	Work Quality, Specification, Measurement and Alignment Check, Daily Progress Meets, Weekly Progress, Monthly Report & Problem Solving - PMC Team; Client Team & Civil Contractor Team after each Activity Completion
141		Release of Shop Drawings for footing work	CIVIL SUPERSTRUCTURE WORKS TO BEGIN
142		Footing Activity - Execution (As Planned Footings)	
143		PEDESTAL ACTIVITIES	

WORK PROCESS COMPARISON - CONVENTIONAL PM METHOD Vs. METHOD IMPLEMENTED HERE Vs. LAST PLANNER METHOD THAT IS RECOMMENDED HERE			
	EXECUTED HERE IN BUILDING 03		EXECUTED HERE IN BUILDING 03
144	Release of GFC for Civil Work (for Pedestal Works) to prepare shop drawings by Civil Contractor & Structural Consultant	157	Footing Activity - Structural Layout & Execution (New Mezzanine Location as per Vastu)
145	Preparation on Civil Shop Drawings for Pedestal works by Structural Consultant (TCE) & Civil Contractor (Arun Excelllo)- Footing Activities	158	Appointment of Vastu Consultant
146	Client Approval & PMC Approval	159	Vastu Consultation
147	Release of Civil Shop Drawings for Pedestal work	160	Relocation of Mezzanine footing by Client & Vastu Consultant
148	Footing Activity - Execution	161	Preparation of Structural Layouts & Details - New Mezzanine Location
149	SOIL FILLING ACTIVITIES	162	Client Approval & PMC Approval
150	PLINTH BEAM ACTIVITIES	163	Preparation of GFC Drawings for Civil Work (for New Mezzanine Location - Footing Works) to prepare shop drawings by Civil Contractor & Structural Consultant
151	Release of GFC for Civil Work (for Plinth Beam Works) to prepare shop drawings by Civil Contractor & Structural Consultant	164	Client Approval & PMC Approval
152	Preparation on Civil Shop Drawings for Plinth Beam works by Structural Consultant (TCE) & Civil Contractor (Arun Excelllo)- Footing Activities	165	Release of GFC Drawings for Civil Work (for New Mezzanine Location - Substructure)
153	Client Approval & PMC Approval	166	Preparation of Shop Drawing for Civil Work (for New Mezzanine Location - Substructure)
154	Release of Civil Shop Drawings for Plinth Beam work	167	Client Approval & PMC Approval
155	Plinth Beam Activity - Execution	168	Release of Shop Drawing for Civil Work (for New Mezzanine Location - Substructure)
156	Work Quality, Specification, Measurement and Alignment Check, Weekly Progress, Monthly Report & Problem Solving - PMC Team; Client Team & Civil Contractor Team after each Activity Completion	169	FOOTING ACTIVITIES
		170	PEDESTAL ACTIVITIES
		171	SOIL FILLING ACTIVITIES
		172	PLINTH BEAM ACTIVITIES
		173	Work Quality, Specification, Measurement and Alignment Check, Weekly Progress, Monthly Report & Problem Solving - PMC Team; Client Team & Civil Contractor Team after each Activity Completion
		174	CIVIL SUPERSTRUCTURE WORKS TO BEGIN

5.1.3 Meetings & Reporting To Be Implemented Based On LPS

Table 5.3: Meetings & Reporting To Be Implemented Based On LPS

Meeting as per LPS			Schedule Based Meetings	Participants during Footing work
Meeting - LPS RPS Meeting / Collaborative Programming Meeting	Occurs at Project start	Discussion & reports	Master Schedule	Client, PMC, Architect, Structural Consultant
		RPS from Master Schedule	RPS Meeting	Client, PMC, Architect, Structural Consultant, Civil Contractor & Land Developer Contractor (Till land development stage) & Design Consultants (for shop drawing preparation)
		Month & 2 weeks Schedule		
SWLA Meeting	Month end	Look ahead window – Prerequisite work, information, resources make ready & constraint log	SWLA Meeting	Client, PMC, Civil & PEB Contractor, Sub Contractor & Design Consultants (When Required)
		Monthly Report		
		WWP, Daily detailed Schedule, Progress- PPC (Weekly, Trade & Monthly); Risk & Root cause Identification & Action Plan		
WWP Meeting	Weekly	DPR – Submitted following day – Client & PMC	WWP Meeting	Client, PMC, Civil & PEB Contractor, Design Consultants (When Required)
		Progress update detailed		
		Work to be done that day		
Production Planning Meeting / Daily Meeting	Daily	Reason for delay & Action plan	Daily Meeting	Daily Progress Report - Client, PMC, Civil & PEB Contractor Daily Huddle Meeting: PMC, Foreman, Labours
		Work to be done that day		
		Progress update detailed		
Daily Huddle Meeting	Daily	Reason for delay & Action plan		

5.1.4 Project Schedule for Civil Substructure PEB & RCC Bldg. to be Implemented

Table 5.4: Project Schedule for Civil Substructure PEB & RCC Bldg.

SINO.	ACTIVITIES – PEB Building	Total Scope of Work	Scope of Work/Day	Duration	Recommended Start	Recommended Finish	Dependency
A			FOOTING				
1	Footing Marking	143 Nos.	6 Nos./ Day	23	01-06-19	23-06-19	
2	Footing Excavation	143 Nos.	4 Nos./ Day	30	02-06-19	02-07-19	1SS+1
3	Footing Soil Dressing	143 Nos.	4 Nos./ Day	30	04-06-19	04-07-19	2SS+2
4	Anti-Termite	143 Nos.	4 Nos./ Day	30	05-06-19	05-07-19	3SS+1
5	Footing Shuttering & PCC	143 Nos.	4 Nos./ Day	30	05-06-19	05-07-19	4SS
6	Footing Marking	143 Nos.	4 to 6 Nos/ Day	29	07-06-19	06-07-19	5SS+2
7	Footing Rebar Work – Footing & Pedestal	143 Nos.	4 to 6 Nos/ Day	27	10-06-19	07-07-19	6SS+3
8	Footing Shuttering	143 Nos.	6 Nos/ Day	24	14-06-19	08-07-19	7SS+4
9	Footing Concreting & Deshuttering	143 Nos.	6 Nos/ Day	23	16-06-19	09-07-19	8SS+2
B			PEDESTAL				
10	Pedestal Starter Marking	143 Nos.	6 Nos/ Day	23	20-06-19	12-07-19	9SS+3
11	Pedestal Starter Shuttering & Concrete	143 Nos.	6 Nos/ Day	23	21-06-19	13-07-19	10SS+1
12	Pedestal -1st Lift Shuttering	143 Nos.	6 Nos/ Day	23	23-06-19	15-07-19	11SS+2
13	Pedestal -1st Lift Concrete	143 Nos.	6 Nos/ Day	23	26-06-19	18-07-19	12SS+3
14	Bolt Fixing	143 Nos.	6 Nos/ Day	23	29-06-19	21-07-19	13SS+3
15	Pedestal -2nd Lift Shuttering	143 Nos.	6 Nos/ Day	23	01-07-19	23-07-19	14SS+2
16	Pedestal -2nd Lift Concrete	143 Nos.	6 Nos/ Day	23	04-07-19	26-07-19	15SS+3
C			FILLING & COMPACTION				
17	Footing Filling & Compaction Layer	143 Nos.	6 Nos/ Day	23	30-06-19	24-07-19	14SS+1
18	Pedestal- Filling & Compaction Layer 01	143 Nos.	6 Nos/ Day	23	14-07-19	06-08-19	17SS+14
19	Pedestal- Filling & Compaction Layer 02	143 Nos.	6 Nos/ Day	23	24-07-19	16-08-19	18SS+10
20	Pedestal- Filling & Compaction Layer 03	143 Nos.	6 Nos/ Day	23	03-07-19	26-08-19	19SS+10
D			PLINTH BEAM				
21	Plinth Beam Marking	879 m	21m/ Day	30	09-08-19	08-09-19	20SS+6
22	Plinth Beam Dressing	879 m	21m/ Day	30	10-08-19	09-09-19	21SS+1
23	Plinth Beam Shuttering & PCC	879 m	21m/ Day	30	11-08-19	10-09-19	22SS+1
24	Plinth Beam Marking	879 m	21m/ Day	30	12-08-19	11-09-19	23SS+1
25	Plinth Beam Reinforcement	879 m	21m/ Day	30	14-08-19	13-09-19	24SS+2
26	Plinth Beam Shuttering	879 m	21m/ Day	30	18-08-19	17-09-19	25SS+4
27	Plinth Beam Concrete	879 m	21m/ Day	30	21-08-19	20-09-19	26SS+3

PROJECT AS RECOMMENDATION – PEB & RCC BUILDING

5.1.5 Method of Implementation of LPS here in Detail

STEP 01- MASTER SCHEDULE

- **Developed by:** Project Manager (EPMCR)
- **Utilizes:** Push system Approach and Experience from similar project
- **Includes:**
 - Overall Schedule
 - All phases
- **Further Proceeding:**
 - Master Schedule
 - Drawing
 - Work Sequence
 - Early warning chart
 - Construction Methodology

Distributed To:

To distribute before RPS Meeting to: Civil Contractor, PEB Contractor, Land development & Compound wall Contractor, Design Consultant & Client

STEP 2-PILOT STUDY - BEFORE RPS MEETING:

- Participants:** Last Planner [Client, PMC, Architect, Civil Contractor & Land Developer Contractor (Till land development stage) & Design Consultants (for shop drawing preparation)]
- Lean concept & Last Planner Procedure
 - LPS Training Provided to: all team members Project Objective linkage with LPS

STEP 3- COLLABORATIVE PROGRAMMING / RPS MEETING:

Participants & developed by: PMC, Client, PMC, Civil & PEB Contractor, Sub Contractor & Design Consultants (When Required)

- **To Develop:** Network of detailed activities in Reverse sequence from Last Activity and the Last Planner
- **Procedure:**

Material Used: Post-its & Long Sheet

- Planners wrote down activities on post-its (1 activity in 1 post-it), Along with individual duration
- Planners stuck those post-its on long sheet as per time line- in backward sequence from the target completion date.
- All Planners:
 - Identify logic between activities
 - Refine the sequence if required by moving post-its
 - Discuss & Decide: Which activity would be on critical path
 - Determine Floats for those activities on critical path & with uncertainties
 - A detailed reverse based schedule is prepared with determination of constraints
 - Further compression of schedule if possible

Note for Step 03: Master Schedule is guide for RPS Production

Collaborative Programming Questions:

- A workplan of what should be done
- An organisation chart - who does what?
- An agreement between trades (or design teams) about when to start and finish
- A logistics plan defining when we need materials, trade teams, drawings etc.
- A tool for workflow control - when we want to do which tasks
- A basis for monitoring progress



STEP 04- SIX WEEKS LOOK-AHEAD (SWLA)

Developed By: PMC, Client, PMC, Civil & PEB Contractor, Sub Contractor & Design Consultants (When Required)

Distributed To: Weekly Work Program Meeting Members

Procedure:

1. It is a 2 weeks or 6 weeks Micro level breakdown schedule with constraints indicated in discussions with other last planners based on RPS & Master Schedule
2. Updated Daily based on progress from actual schedule
3. Documenting constraints with indication by the PM & Create lookahead window and Constraint log
4. Performed Constraints Analysis & Remove Constraints using ADM Model

ADM Model:

Constraints Identification and removal before Activities start, Aids Make Ready Planning to check availability of resources, information and prerequisite for next 2 to 6 weeks, Through Look Ahead window maintaining constraints log.

Primary Category of constraints includes:

1. **Directives:** Guidance / information to be available for the work to be done or assessed or produced
2. **Prerequisite work:** Work to be done prior to the activity to take place successfully
3. **Resources:** Man, Material, Equipment and tools and Money

Visualisation: Locating Constraint Logs, Look Ahead Window and Make ready Plan at common points can helps to maintain schedule on track and Complete activity with lead time within the given duration with no delay

4. PRODUCTION MANAGEMENT

Conducted by: Site Project Manager

Participants:

Daily Huddle Meeting: Site Project Manager, Contractor, Subcontractor & Labours

Daily Progress Reporting: Site Project Manager, PMC Team (Offsite), Client, Design Team (If Required)

Procedure:

A daily stand-up meeting on-site or a brief morning telephone conference to let everyone know what was completed yesterday, allows early warning of any late (or early) deliveries and enables the team to identify root cause and solve the problem, quickly renew or adjust plans & promises based on this new information.

Set of questions for each foreman at their morning meeting:

- Which promises did you deliver since the last meeting?
- Which promises are or will be late (or more than 24 hours early), and when do you expect to get them done?
- Which promises will you complete before the next meeting?
- What concerns or constraints do you have regarding your work?
- Are you on track to meet the overall work plan?

STEP 05- WEEKLY WORK PLAN (WWP)

Project 01 Participants: Client, PMC, Civil & PEB Contractor, Design Consultants (When Required)

Procedure: Each trade submits its own upcoming week's schedule to the Project Manager on the day before WWP Meeting. Last planners only promise once they have clarified the conditions of satisfaction, including the due date, and are clear that the task can be done i.e. they have the capability, materials, labour, information, etc. to do the work .

Meeting Addresses:

- a. Work to be done for the week; Weekly PPC & Production Plan
- b. Issues of Planning Process such as:
 - Schedule,
 - Manpower,
 - Material,
 - Equipment Availability
 - Safety
 - Construction Methodology,
 - Early warning Charts,
 - Other Problems from job site
- c. First Run Studies - Identify root causes and solving Problem It enhances open 2 way communication
- d. Once the task is complete the last planner responsible declares delivery so that site management or the team responsible for the next task can make an assessment as to whether it meets the Conditions of Satisfaction or not.
- e. Prerequisite (Task & Forecast)

STEP 06- PERCENTAGE PROJECT COMPLETED (PPC)

Prepared by: Site Project Manager

Distributed To: Last Planners in WWP Meetings

On Basis Of: Daily, Week Basis, Monthly, Trade Basis, Overall Project Basis

Done By:

Comparing every week progress and update on original schedule with actual schedule (Actual Start & Finish) : WWP Schedule and Variance Control table & Analysing them

Procedure:

It is an evaluation process in a PPC meeting. , the learning conversations encourage learning from both success & failure so as to reduce the risk of repeated failures and we systematically learn how to work more effectively together more predictable and reliable workflow.

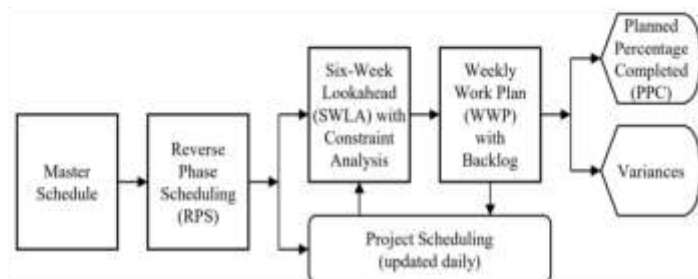


Fig 5.2 Method of Implementing LPS here in Detail

5.2 RECOMMENDATIONS – LAST PLANNER SYSTEM BASED TEMPLATES

5.2.1 Last Planner System based Templates

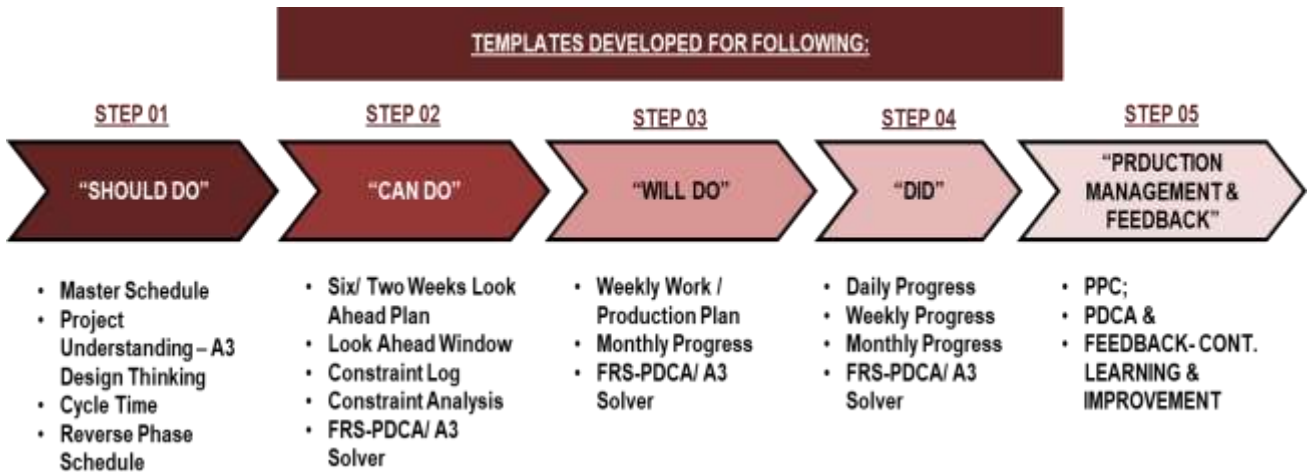


Fig 5.3 LPS Templates Developed on the following basis

A3 Problem Solver/ Design Thinking

A3 Design Thinking Formats Created Based On Understanding The Formats Which Are Used At EPMCR, Chennai, To Use A3 Sheets as:

- Design Thinking Sheets To Understand The Project & Evolve Ideas / Solution
- Understanding Challenges, Their Root Cause/ Pain Point, ,Empathize & Ideate To Provide Solution - PDCA Approach
- Implement, Report The Progress / Test Report, Document Them, Get Feedbacks & Act / Adjust To Undergo Continuous Improvement In Collaborative Approach Of All The Stakeholders.

A3 Design Thinking Format Thus Includes Following Typologies:

1. A3 Understanding- Understanding Project Requirement
2. A3 Empathize Sheet
3. A3 Project Milestone Identification & Process
4. A3 Ideating Sheet
5. A3 Solution Sheet
6. A3 Solver

Fig 5.4 A3 Problem Solver

Table 5.5: Last Planner System based Templates

**TEMPLATE 01: A3 UNDERSTANDING/ DESIGN THINKING SHEET (SHOULD DO)-
BASED OF MASTER SCHEDULE FOR RPS**

A3 - SHEET 1						
DESCRIPTION OF PROJECT / WORK / ACTIVITY / TASK				CLIENT NAME & DESCRIPTION		
WORK SCOPE	WORK METHODOLOGY			TECHNOLOGIES / TRENDS		
IMPORTANT FACTS - PROJECT / USER/ CLIENT	TIME	COST / BUDGET	QUALITY	RESOURCES	PRODUCTIVITY REQUIRED	CONSTRAINTS

A3 - SHEET 1 CONT.					
AUTHOR:	SUPPORT TEAM		DATE:	TITLE	
			REV.NO:		
ACTIVITIES INVOLVED	TIME FRAME	INTERNAL STAKEHOLDERS	ACTIVITIES INVOLVED	TIME FRAME	EXTERNAL STAKEHOLDERS
PLACES - 1. SITE / PROJECT, 2.MATERIAL & EQUIPMENT, 3.STAKEHOLDER BASED					

this is what we will do

this is what we need to do it

*what will be done?
where?
by whom?
how long?*

*What's needed to do it?
from whom?*

people
information
equipment
materials
prior work
safe external conditions
safe space
+ *shared understanding*

**TEMPLATE 02: PROJECT MILESTONE & INFORMATION FLOW PROCESS IDENTIFICATION FOR GFC TO SHOP DRAWING PREPARATION
STAGE (SHOULD DO TO CAN DO)**

A3 SHEET 02 - PROJECT MILESTONE IDENTIFICATION & PROCESS												
CURRENT - PROJECT MILESTONE & PROCESS AND RESPECTIVE PROBLE IDENTIFICATION												PMC Company- ABC Company
DESCRIPTION OF PROJECT Schwing Stetter, Kanchipuram			CLIENT NAME Schwing Stetter		AUTHOR: Munisha N	SUPPORT TEAM PMC, Civil Contractor, DC	DATE: 12-04-21 REV.NO:	TITLE Footing Substructure Civil Work- Information Flow				
SL NO.	ACTIVITY	OVERALL TIME LINE	STATE HOLDER / RESPONSIBLE MANAGER	INPUT / INFORMATION FLOW - DESIGN, DRAWINGS & COMMUNICATION	INFLOW TIME	TOOLS & TECHNOLOGY - INFLOW	OUT FLOW - DESIGN, DRAWINGS & COMMUNICATION	OUTFLOW TIME	TOOLS & TECHNOLOGY - OUTFLOW	WORK FRONT AVAILABILITY & CONDITIONS	WORK METHOD - QUALITY, SAFETY & PRODUCTIVITY	PROBLEM
01	Footing Excavation Drawings	26-04-2021 to 01-04-2021	Design Consultant; Civil Contractor	GFC Drawing- Footing & Civil Drawings	26-04-2021	Auto Cad & Pdf-Footing Coordination	Shop Drawing- Footing Layouts	01-04-2021	01-04-2021	Auto Cad & Pdf – Footing Shop Drawings	If Any to Achieve	Constraints if Any to be removed

**TEMPLATE 03: CIVIL WORK (SUBSTRUCTURE) – CYCLE TIME, DURATION, INTERDEPENDENCIES AND MANPOWER & EQUIPMENT
REQUIREMENT CALCULATION (SHOULD DO TO CAN DO)**

CYCLE TIME, DURATION, INTERDEPENDENCIES AND MANPOWER & EQUIPMENT REQUIREMENT CALCULATION												
SL. No	Activities	Activity Predecessor	Cycle time calculated for quantity	Cycle Time			Total			Manpower & Machinery		
				In Mins	In Hrs.	Per Day Avg. Hrs	Total Quantity	Duration Required	Planned Description	Team Members	Quantity	Duration
01	Excavation	Marking	1 No of Footing	180	3	Average Calculated for- • Working Hour: 12 hrs/ Day; • Work Scope per day: 6 Footings/ Day	143 Nos	23/ 30 Days	Excavator Team	Excavator	1	23/ 30 Days

TEMPLATE 04: LOOK AHEAD SCHEDULE – 2 / 6 WEEKS BASIS- USED AT BIG ROOM (ONLINE/OFFLINE) & AT SITE (CAN DO)

WORK PACKAGES		MONTH 01											
		WEEK 01				WEEK 02				WEEK 03			
Package 01	Activity ID	ABXX											
	Activity Name	Footings Excavation											
	Location Id	GRID A= 1-6											
	Structure Id	C1, C2, C3, C4, C5, C6											
	Scope Quantity	6 Nos											
	Resources	Excavator, JCB, Tipper, Helper											
	Resp. Person	Excavator, Civil Contractor											
	Predecessor	Footings Marking											
	Successor	Soil Dressing Grid A= 1-6											
	Activity ID												
Package 02	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
	Successor												
	Activity ID												
	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
	Successor												
	Activity ID												
	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
	Successor												
	Activity ID												
	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
	Successor												
	Activity ID												
	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
	Successor												
	Activity ID												
	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
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	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
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	Resp. Person												
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	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
	Successor												
	Activity ID												
	Activity Name												
	Location Id												
	Structure Id												
	Scope Quantity												
	Resources												
	Resp. Person												
	Predecessor												
	Successor												

TEMPLATE 05: MAKE READY PLAN/ LOOK AHEAD WINDOW – 2 / 6 WEEKS BASIS (CAN DO – FOR CONSTRAINT ANALYSIS)

MAKE READY PLAN/ LOOK AHEAD WINDOW													
Company		ABC Company		Project		YYYY Project, Location		Phase		Footings Substructure Civil Work		Area	
Author		Monisha Nageswaran		Date of Preparation		02-05-2021		Proposed Week Span		1 Week / 2 Weeks ; Date: 03-05-2021 to 09-05-2021 (1 Week) / 03-05-21 to 16-05-21 (2 Wk)		RCC Building	
Stakeholders		PMC Team, Civil Contractor, Sub Contractor, Vendor, DC		Information		Prerequisite		Resources		Workfront		Note	
Sl. No.	Task Description	Activity Detail		Contract/ Information		Design		RFI		Method Statement		Weather	
		Progress Start Date As Planned	Responsible Person	Contract/ Information	Design	RFI	Method Statement	Weather	Task	Labour	Material	Equipments	Space
1	Excavation	03-05-21	Excavator	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

TEMPLATE 06: CONSTRAINT LOG BASED ON LOOK AHEAD WINDOW – 2 / 6 WEEKS BASIS (CAN DO – FOR CONSTRAINT ANALYSIS)

CONSTRAINT LOG						
Company	ABC Company	Project	YYYY Project, Location			
Author	Monisha Nageswaran	Phase	Footing Substructure Civil Work			
Date of Preparation	19-04-2021	Area	RCC Building			
Stakeholders	PMC Team, Civil Contractor, Vendor, DC	Proposed Week Span	03-05-2021 to 09-05-2021 (1 Wk)			
Sl. No.	Constraints	Due Date	Responsible Person			
1	Footing Coordination Drawing	02-05-21	Architect & Structural Consultant			

TEMPLATE 07: WEEKLY PREREQUISITE (TASK BASED) - WEEKLY BASIS DERIVED FROM MAKE READY PLAN/ LOOK AHEAD WINDOW (CAN DO TO WILL DO)

PROPOSED PRODUCTION PLAN												
Company	ABC Company	Project	YYYY Project, Location									
Author	Monisha Nageswaran	Phase	Footing Substructure Civil Work									
Date of Preparation	02-05-2021	Area	RCC Building									
Stakeholders	PMC Team, Civil Contractor, Sub Contractor, Vendor, DC	Week Commencing	1 Week; Date: 03-05-2021 to 09-05-2021 (1 Week)									
Sl. No.	Task Description	Make Ready Needs	Responsible Person	When will the Work be done?								
		What must be done prior to release of task		Mon	Tue	Wed	Thu	Fri	Sat	Sun		
1	Footing Excavation	Footing Marking	Surveyor, Excavator, Contractor	6 Nos	6 Nos	6 Nos	6 Nos	6 Nos	6 Nos	6 Nos		

TEMPLATE 08: CONSTRAINT ANALYSIS & EMPHATIZE SHEENT (CAN DO/ WILL DO/ DID- CONSTRAINT ANALYSIS)

A3 SHEET 03 - EMPHATIZE SHEET						
DESCRIPTION OF PROJECT / WORK / ACTIVITY / TASK				AUTHOR:	DATE: 26-04-2021 REV. NO:	TITLE
Footing Work				Monisha N		Civil Substructure- Footing
INTERNAL STAKEHOLDERS						
STAKEHOLDER NAME	ACTIVITY	ROLES & RESPONSIBILITIES	WHAT DID YOU HEAR	WHAT DID YOU OBSERVE	KEY CHALLENGES / CONSTRAINTS - "I WONDER IF THAT MEANS"	PROBLEMS
- Client - Design Consultant - Contractor - PMC	Footing Marking	Surveyor	- Cont. Rain Fall - Inadequate Coordination - Dwg. Lack of Labour Availability	- Ideal Labours during Rain - Lack of proper Coordination Drawing	- No proper Labour & Weather Forecast - Improper Information flow - Lack of Collaboration & Coordination between DC	Improper Weather & Labour Forecast; Lack of timely Information flow & collaboration
						Proper Weather & Labour Forecast; Timely Information flow; Collaboration & Coordination
EXTERNAL STAKEHOLDERS						
STAKEHOLDER NAME	ACTIVITY	ROLES & RESPONSIBILITIES	WHAT DID YOU HEAR	WHAT DID YOU OBSERVE	KEY CHALLENGES / CONSTRAINTS	PROBLEMS
- Vendor - SIPCOT - Govt. CMDA	Footing Marking	Surveyor	Lack of Timely Approval	- Late Procurement of Land - Delayed Submission for Approval	- Procurement of Land is not done timely - Lack of Transparency of Information Flow by SIPCOT to Client	Late Procurement; Lack of Transparency by SIPCOT to Client
						Proper Sequencing of Activities- Land Procurement & Approval
OVER ALL PROBLEM DEFINITION						
Improper Weather & Labour Forecast; Lack of timely Information flow; Collaboration & Coordination of Participants; Late Procurement and Lack of Transparency by SIPCOT to Client						

TEMPLATE 09: IDEATING SHEET WITH 2 OR MORE IDEAS TO DERIVE SOLUTION TO REMOVE THE CONSTRAINT (CAN DO-IDEA GENERATION FOR ANALYSED CONSTRAINTS)

A3 SHEET 04 - IDEATING SHEET											
DESCRIPTION OF PROJECT		CLIENT NAME		AUTHOR:	SUPPORT TEAM	DATE: REV.NO:	TITLE				
HOW MIGHT WE...? (IDEAS FOR OVERCOMING CHALLENGES)											
SL NO.	ACTIVITY	OVERALL TIME LINE	STAKE HOLDER/ RESPONSIBLE MANAGER	INPUT / INFORMATIO FLOW - DESIGN, DRAWINGS & COMMUNICATION	INFLOW TIME	TOOLS & TECHNOLOGY - INFLOW	OUT FLOW - DESIGN, DRAWINGS & COMMUNICATION	OUTFLOW TIME	TOOLS & TECHNOLOGY - OUTFLOW	WORK FRONT AVAILABILITY & CONDITIONS	WORK METHOD - QUALITY, SAFETY & PRODUCTIVITY

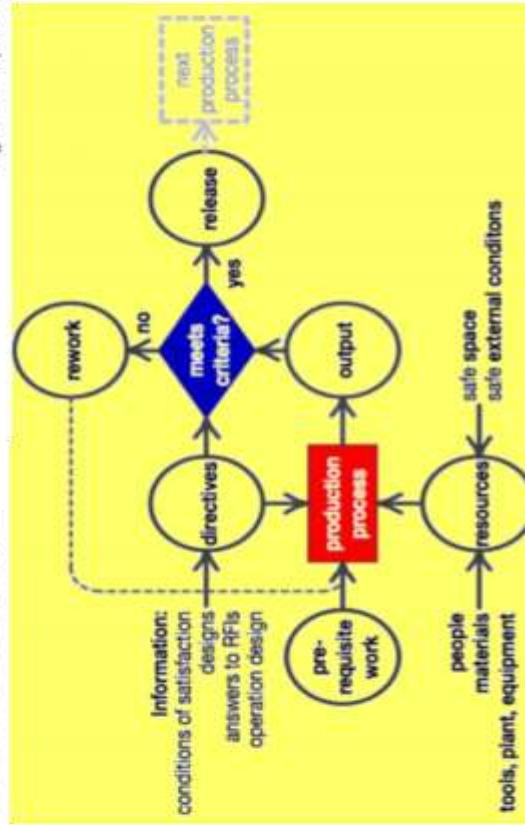
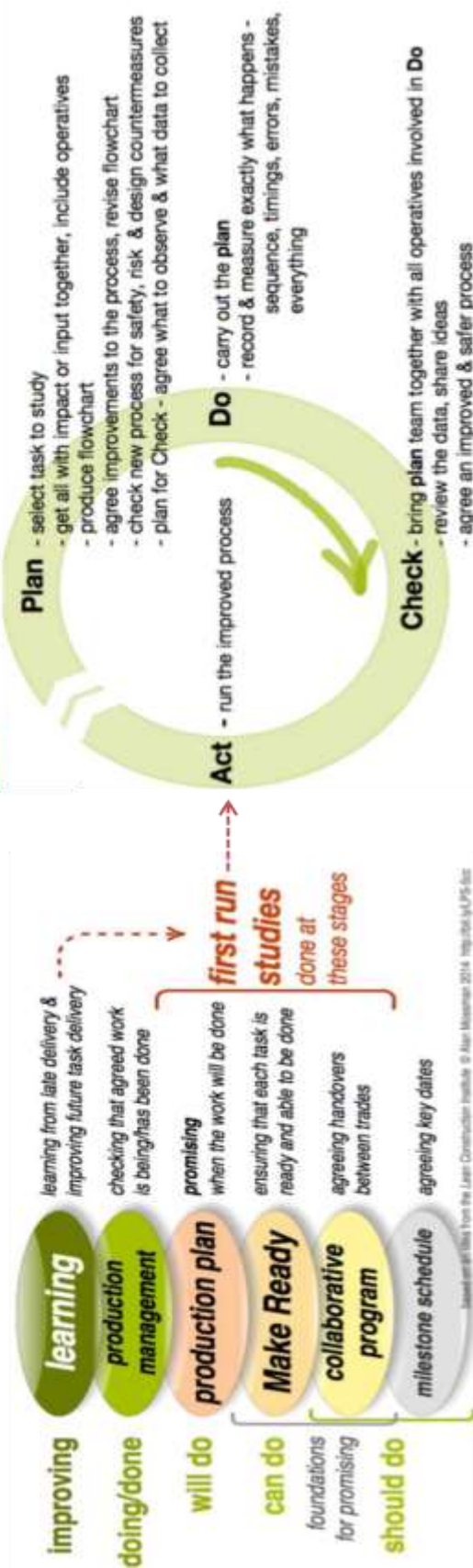
TEMPLATE 09: SOLUTION SHEET WITH 1 OR 2 SOLUTION SORTED BY CBA FROM IDEAS GATHERED IN BEFORE STEP TO REMOVE THE CONSTRAINT (CAN DO/WILL DO/ DID- SOLUTION FOR ANALYSED CONSTRAINTS)

A3 SHEET 05 - SOLUTION SHEET					
DESCRIPTION OF PROJECT / WORK / ACTIVITY / TASK		AUTHOR:	SUPPORT TEAM	DATE:	TITLE
Footings Work – Footing Marking		Monisha N	PMC, Client, Contractor, Surveyor, SIPCOT, Design Consultant	26-04-2021 REV.NO:	Civil Substructure- Footing Solution Sheet
ACTIVITY NO & NAME Footing Marking		OVERALL PROBLEM STATEMENT Improper Weather & Labour Forecast; Lack of timely Information flow, Collaboration & Coordination of Participants; Late Procurement and Lack of Transparency by SIPCOT to Client			
THE PROBLEM (TO BE SOLVED) HOW MIGHT WE... By proper Weather & Labour Forecast; To establish timely Information flow, Collaboration & Coordination of Participants; Avoid Late Procurement and Lack of Transparency by SIPCOT to Client		THE USERS / STAKEHOLDER THE USERS THAT WE ARE TARGETING ARE PMC, Client, SIPCOT, Contractor, Surveyor, Design Consultant			
THE USER PAIN POINTS / NEEDS ARE Pain Points: Ideal Labours during Rain; Lack of proper Coordination Drawing; Late Procurement of Land & Delayed Submission for Approval Needs: Proper Weather & Labour Forecast; Timely Information flow; Collaboration & Coordination; Proper Sequencing of Activities- Land Procurement & Approval		THE SOLUTION OUR SOLUTION WORKS LIKE THIS Proper Weather & Labour Forecast helps to Avoid Ideal Labour Condition during Rain and Proper Availability of Labour; Transparency and Proper Sequencing of activities helps to reduces delay due to Land Procurement Early Collaboration & Coordination of all the Participants			
THE IMPACT THE BENEFITS OF THE SOLUTION IS		THE ACTORS OUR SOLUTION INVOLVES		THE REVENUE OUR SOLUTION GENERATES PROFIT BY	
- Reduced Delay - Proper Labour Utilisation - No Backlogs		- Proper Weather- PMC Team - Labour Forecast- PMC Team - Timely Information flow and Collaboration & Coordination – All the Project Participants; - Proper Sequencing of Activities- PMC Team - Land Procurement & Approval – SIPCOT, Client			
		OVER ALL COST & TIME FRAME		WORK METHOD - QUALITY, SAFETY & PRODUCTIVITY	

TEMPLATE 10: SOLVER SHEET WITH FINAL SOLUTION TO REMOVE THE CONSTRAINT ["CAN DO / WILL DO/ DID" - SOLUTION FOR ANALYSED CONSTRAINTS USING PDCA (Plan-Do-Check-Act) APPROACH]

A3 SHEET 06 - SOLVER									
PROJECT TITLE		CLIENT NAME	AUTHOR:	SUPPORT TEAM					
Schwing Stetter Global Concrete pump manufacturing facility		Schwing Stetter	Monisha N	PMC, Client, Contractor, Surveyor, SIPCOT, Design Consultant, Land Developer					
ACTIVITY NAME & NO.			DATE:	TITLE					
Footing Work – Footing Marking			25-04-2021	Civil Substructure- Footing Solution Sheet					
STAKEHOLDERS			COUNTER MEASURE	DESCRIPTION	BENEFIT	SUPPORT			
PMC, Client, Contractor, Surveyor, SIPCOT, Design Consultant			Proper Weather & Labour Forecast Transparency ; Collaboration & Coordination	Proper Weather & Labour Forecast to Avoid Ideal Labour during Rain; Transparency & Proper Sequencing of activities helps to reduces delay with Early Collaboration	Reduced Delay Proper Labour Utilisation No Backlogs	PMC, Land Developer, Surveyor, Contractor, Design Consultant			
CURRENT CONDITIONS			CHALLENGES / ASPIRATIONS / IDEAS						
Ideal Labours during Rain; Lack of proper Coordination Drawing; Late Procurement of Land & Submission for Approval			Aspiration- Proper Weather & Labour Forecast; Timely Information flow; Collaboration & Coordination; Proper Sequencing of Activities- Land Procurement & Approval						
PROBLEM Improper Weather & Labour Forecast; Lack of timely Information flow, Collaboration & Coordination of Participants; Late Procurement and Lack of Transparency									
GOALS / TARGETS			DEPENDENCIES	RESOURCES					
Reduced Delay/ Non- value Added Activity.			Successor- Excavation	Surveyor- 3 Nos					
Proper Resource Allocation; Information Availability & Prerequisites			CONRAINTS: Prerequisites; Information	PRODUCTIVITY 6 Nos/ Day					
REASON ANALYSIS			CHECK						
- Cont. Rain Fall; Ideal Labour - Inadequate Coordination Dwg. - Lack of Labour Availability - Lack of Timely Approval			Testing						
ACT - LEARN - IMPROVE			Feedback & Method of Improvement and Continuous Learning						

FRS (First Run Studies) - PDCA APPROACH FOR TEMPLATE 11 & 13 WITH FINAL SOLUTION TO REMOVE THE CONSTRAINT & FEEDBACK FOR CONTINUOUS LEARNING & IMPROVEMENT [CAN DO / WILL DO - SOLUTION FOR ANALYSED CONSTRAINTS USING PDCA (Plan-Do-Check-Act) APPROACH]



TEMPLATE 11: WEEKLY WORK PLAN / PRODUCTION PLAN -FOR BIG ROOM (ONLINE/ OFFLINE) & AT SITE (WILL DO)

Activity ID	ABXX	Activity ID
Activity Name	Footing Excavation	Activity Name
Location Id	GRID A= 1-6	Location Id
Structure Id	C1, C2, C3, C4, C5, C6	Structure Id
Quantity to complete & Remaining	6 Nos	Quantity to complete & Remaining
	2 Nos	
Resources	Excavator, JCB, Tipper, Helper	Resources
Resp. Person	Excavator, Civil Contractor	Resp. Person
Predecessor	Footing Marking	Predecessor
Successor	Soil Dressing Grid A= 1-6	Successor

Color Codes For Week Each Day Basis

<u>Week 01</u>	<u>Week 02</u>	<u>Week 03</u>	<u>Week 04</u>	<u>Week 05</u>	<u>Week 06</u>	<u>Week 07</u>																																																																																																																																																																																																																																																																																																																																																																																										
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TEMPLATE 12: WEEKLY WORK PLAN / PRODUCTION PLAN (WILL DO)

COMPANY NAME		EPMCR, CHENNAI			PROJECT TITLE		PARTICIPANTS																																																																																																																																				
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TEMPLATE 12: CIVIL WORK (SUBSTRUCTURE) – DAILY PROGRESS REPORT, REASON FOR DELAY & PROBLEM SOLVER (DID – DAILY PRODUCTION MANAGEMENT WITH PPC AND PDCA (FISHBONE ANALYSIS), FEEDBACK FOR CONTINUOUS LEARNING & IMPROVEMENT)

DAILY PROGRESS REPORT / UPDATE SHEET WITH PROBLEM SOLVER (PDCA)							
Project ID & Name	Schwing Stetter					Date:	05-04-2021
Stakeholder:	PMC, Client, Contractor, Subcontractor, Vendor						
Current Condition:							
Project Status		Progress (Planned Vs. Achieved)			Manpower (Planned Vs. Available)		
Description	Total Quantity	Planned	Achieved	Backlog	Planned	Available	To Increase
Footing Excavation	143 Nos	6 Nos	3 Nos	3 Nos	1- Excavator	1	0
Reason for Backlog							
Prerequisite	Resources	Information	Quality	Safety	Others		
Soil Test- Improper	Nil	Shop Dwg	Nil	Improper Lighting	Nil		
Weather Forecast							
Target Condition / Measurable Objective				Status Achieved as per Schedule			
Sl. No.	Description	Total	To Complete (Overall Scope)		Balance		
1	Footing Excavation	143 Nos	143 Nos		110 Nos		
Remarks							
Root Cause Analysis							
Fish Bone Diagram							
Recommendation							
Example: Proper Weather Forecast & Provide Proper Lighting and Availability of Shop Drawing							
Counter Measures							
Sl. No.	Task				Responsibilities	Due Dates	
1	Proper Lighting during night				Contractor	On Night	
2	Proper Soil Testing				Geotechnical Team	Immediate	
Implementation Plan - Day Wise Catchup							
Activity	Month 1 Work Quantity						
	Week 01 Work Quantity for each day						
	Day 01	Day 02	Day 03	Day 04	Day 05	Day 06	Day 07
Excavation	6 Nos	6 Nos	6 Nos	6 Nos	6 Nos	6 Nos	6 Nos
Project Results							
Activity	Current Rate / Day	Req Rate/ Day as per Catchup Plan	Req Quantity to plan for Upcoming days in that Week	Estimated Duration	Estimated Start Date	Estimated Completion Date	
Excavation	3 Nos	6 Nos	7 Nos- for next 3 days	3 Nos	06-04-21	09-04-21	
Site Photos							

TEMPLATE 13: CIVIL WORK (SUBSTRUCTURE) – WEEKLY PROGRESS REPORT, BACKLOG & REASON FOR DELAY (DID WITH PROGRESS, RESOURCE & DELAY ANALYSIS WEEKLY BASIS)

WEEKLY PROGRESS REPORT - WEEKLY PROGRESS, BACKLOG & REASON FOR DELAY																				
MANPOWER																				
Sl. No.	Activity	Manpower							PMC Recommendation											
		1 Week Availability							Available Manpower	Required Manpower	Nos.	To Increase	Responsibility							
1	Barbender	5 Nos	5 Nos	8 Nos	8 Nos	8 Nos	8 Nos	8 Nos	7 Nos	16 Nos	9 Nos		Civil Contractor							
MACHINERY																				
Sl. No.	Activity	Machinery							PMC Recommendation											
		1 Week Availability							Available Machinery	Required Machinery	Nos.	To Increase	Responsibility							
1	Excavator	0	1 No	1 No	1 No	1 No	1 No	1 No	1 No	1 No	0		Contractor							
PROGRESS																				
Sl. No.	Activity	Progress							Weekly Progress											
		1 Week Progress							Average Rate	Required Rate	Wk. Progress	Cumulative								
1	Footing Excavation	3 Nos	6 Nos	3 Nos	0	0	0	0	3 Nos	6 Nos	12 Nos	143 Nos								
BACKLOG																				
Sl. No.	Activity	Progress							Reason for Delay											
		1 Week Backlog																		
1	Footing Excavation	3 Nos	1 No	4 Nos	4 Nos	4 Nos	4 Nos	4 Nos		Improper Soil Study; Lack of Labour Availability										

**TEMPLATE 14: CIVIL WORK (SUBSTRUCTURE) – MONTHLY PROGRESS REPORT & OVERALL PROJECT PPC TILL TO DATE (DID
WITH PPC FOR THE PROJECT MONTHLY BASIS)**

MONTHLY PROGRESS REPORT & OVERALL PROJECT PPC TILL TO DATE									
Project Status on		STATUS TILL TO DATE							
Sl. No	Work Packages:	Grid / Location / Workfront:			Delay Analysis:			Est. Completion:	
	Footing Work	Work front 01- 42 Numbers							
	Activities	Planned	Actual	Delay	% Progress	End Date	No. of Days Extended	Duration	End Date
1	Footing Excavation	42 Nos	42 Nos	0 No	100%	Nil	Nil	Nil	Nil

MONTHLY PROGRESS REPORT & OVERALL PROJECT PPC TILL TO DATE - CONTINUITY									
OVERALL PROJECT STATUS TILL TO DATE									
Overall Project Status				Overall Delay Analysis			Est. Tot. Completion (Handover to PEB)		
Planned	Completed	Incomplete	% Progress	Scheduled End Date	No. of Days Ext.	Duration	End Date		
114 Nos	110 Nos	4 Nos	96%	05-05-21	1 Days	31 Days	06-05-21		

5.3 CONCLUSION

Table 5.6: Recommended Project Schedule by Using LPS for PEB & RCC Building-Overview

RECOMMENDED SCHEDULE BY IMPLEMENTING LAST PLANNER SYSTEM & OVERALL DURATION							
Sl.No.	ACTIVITIES	As Built Schedule		Recommended Schedule			
		Duration-PEB	Duration-RCC	Delay- PEB	Delay- RCC	Duration	Finish Date
A							
1	Footing	148	133	181	367	39	01-06-19
B							
2	Pedestal	95	100	83	374	67	20-06-19
C							
3	Filling & Compaction	95	92	123	364	57	30-06-19
D							
4	Plinth Beam	106	90	147	367	30	09-08-19
	OVERALL DURATION	Actual Start to End 28 th Sep 2019 – 2 nd Nov 2020		Actual Duration	Actual Delay	Rec. Duration	Rec. Start to End
				400	281	109	01-06-2019 To 20-09-2019
OVERALL DURATION REDUCTION BY LPS (Last Planner System) COMPRESSION AFTER RPS (Reverse Phase Scheduling) BY COLLABORATION							
	By Applying Lean Compression – 20 % Compression Ref. From Case Studies					88 Days Duration	
	By Applying Lean Compression – 15 % Compression Ref. From Case Studies					93 Days Duration	
	By Using Lean Based Last Planner System, Time Management & Schedule Reliability can be Increased By					90%	

5.3.1 Conclusion

As seen from the literature study and as per Lean Construction Institute nearly 70% of the projects during Construction suffer from delayed project delivery due to Conventional Construction Project Planning System which are unsuitable for fast, Complex, Dynamic and Uncertain Projects with Multiple Stakeholders.

By Adopting Collaborative and Commitment based Construction Project Management System such as Lean's Last Planner System for Planning, Scheduling and Tracking the reliability of the Project Schedule can be Increased by 90% and Complete the project within the determined/ Commitment duration during Collaborative Reverse Phase Scheduling. Also by collaboration and maintaining accountability by Implementing LPS we can further decrease the duration by 15% to 20%. Further Last Planner System states the need for balance between Transformation, Value Generation and Continuous Information Flow by Macro and Micro level Planning (Part to Whole and Visversa and Continuous Improvement and Learning- Should do, Can do, Will do, Did and Feedback) that gives Importance to:

1. Early and Continuous Collaborative Meetings with all the stakeholders (Contractors, Vendors, Design Consultants, Client, PMC Consultants) during both the design and construction stage.
2. Implementation of Proactive and Root cause Problem Solver and Design Thinking approach A3's that Uses PDCA (Plan, Do, Check, Act).
3. Constraints Analysis, Maintaining Constraints Log and Constraints Removal before through proactive approach before the activity occurs during Make Ready Plan / 2 to 6 Weeks look ahead Schedule.
4. Provision of Weekly Work Plan and Progress by the Contractors.
5. Daily Labour and Progress Report to the PMC
6. Maintaining Project Complete (PPC)- Trade based, Daily, Weekly, Monthly and Overall Project based to understand the progress and challenges faced during the process and to provide solution from root cause analysis to be on track with the proposed schedule and update the schedule based on current requirements and project's predetermined duration as per Master Schedule.
7. First Run Studies for Proactive Constraint Analysis
8. Visualization at common spaces and along the Construction Site for Continuous Updates, Motivations, Increase Safety and to maintain the project on track as per Stipulated Time, Cost, Resources, Quality and Scope.

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