How can Lean Philosophy Improve the Traditional Philosophy of Project Management

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Abstract

The construction industry is suffering with many problems nowadays. Many projects are getting failed and getting over budget. It has been generally noticed that chaos in construction industry is only because of the absence of explicit theory of project management. The paradigm of project management in construction is still following mass production, which means considering only conversion activities. The present style of conventional project management is based on two fundamental theories i.e. management-as-planning (for planning and execution) and thermostat model (for control).

The new philosophy (lean production) considers production both conversion and flow processes. The focus of lean production is to reduce flow processes, to improve the conversion processes, and to reduce the wastes during production.

Among all other lean tools, this document is focusing on Last Planner System (LPS) for the production control system. In the end of the document, two case studies have been mentioned in which it is clearly demonstrated that, when project managers used the LPS the value of PPC (percent planned completed) and PF (performance factor) have been more salubrious as compared to the absence of LPS during the execution of the project.

Keywords

Conventional project management, anomalies of project management, lean production, Last Planner System (LPS).

1. Introduction

The history of the construction industry is very old and historical; it starts from pyramids of Egypt and finishes with tall buildings of the modern world. Evolution has occurred in construction and also many more techniques have been invented to help the construction industry. But somehow it sounds like the development in construction got stuck somewhere. The problems in the construction industry nowadays are very well known to everybody. The projects are lagging behind schedule, running late, over budgeted and end with failure. It is very difficult for project managers to finish the project before the deadline date.

The construction industry is considered to be a most complex and uncertain industry nowadays, because of its turbulent nature and mood. Occupational safety is notoriously worse than in other industries [1]. The “theory of mass production” ruled the construction industry for a long time until now. This theory is based on transformation, where production can be seen as a number of discrete steps, each independently adding to the value of the product. Till today in the construction industry procurements are made
accordingly. The lowest price for each operation, order, contract or purchase is expected to lead inevitably to the lowest total cost for the project as a whole [2].

The PMI (Project Management Institute) provided a common lexicon within the profession and practice for talking and writing about project management, the guide is called “A Guide to the Project Management Body of Knowledge” (PMBOK Guide). The purpose of this book was to provide a subset for project managers of any project. This document describes project management in terms of its component processes and their interaction [3]. The project management knowledge areas are as follows.

1- Project Integration Management  
2- Project Scope Management  
3- Project Time Management  
4- Project Cost Management  
5- Project Quality Management  
6- Project Human Resource Management  
7- Project Communications Management  
8- Project Risk Management  
9- Project Procurement Management

According to PMBOK Guide projects are composed of two kinds of processes i.e. project management process and product-oriented process. Project management processes are further divided into initiating, planning, and execution, controlling, and closing processes.

But here the question arises that why do projects fail, even if they follow the processes of PMBOK? This question made all researchers and project managers think about the renovation, adding some other techniques or inventing some new techniques which can help the drowning reputation of construction industry. Many countries suffered from this problem and they started hunting for its improvement e.g. Denmark, Netherlands etc.

It is popularly held that project management originated in construction. If we are talking about modern project management, it is not strictly true. There is surprising diversity of views on what does project means? One of the gurus of project management describes a project as an execution of certain tasks within certain specifications with defined starting and finishing dates, funding limits and which takes in resources e.g. money, people and equipment etc. A Guide to Project Management, defines a project as “a unique set of coordinated activates, with definite starting and finishing points, undertaken by an individual or organization to meet specific objectives within defined schedule, cost and performance parameters”. All definitions are revolving around start date and end date, the gist is probably clear [4]. Research carried out in the USA and at Oxford in the 1980s showed many factors that cause project to meet their schedule or cost targets are not covered by the PMBOK. The main factors which cause projects to fail to meet their baseline targets are things like client driven changed specifications or order quantities, technology problems, poor design management, external price changes, environmentalist, community or political difficulties, geotechnical problems, weather, and labor problems.
Among them very few have been addressed in much of the project management literature. PMBOK material is helpful in managing projects, but is not sufficient to managing them successfully [4].

Manufacturing has been a reference point and a source of innovation in construction for many decades. For example, the idea of industrialization comes from manufacturing. Currently computer integration and automation also have their origin in manufacturing. Nowadays there is a new trend developing in manufacturing, which is far better than that of information and automation technology. This trend is based on new production philosophy rather than new technology, and stresses the importance of basic theories and principles related to production processes [1].

The construction industry took very little interest in this new concept. The aim and topic of this document is to assess whether or not this new concept or new philosophy of production has any impacts on the construction industry?

This document will also briefly explain the traditional way of construction and its management, whilst including some case studies of different companies from different countries. It will explain why the PMBOK and its processes aren’t able to improve the chaotic situation in the construction industry. Also how this new concept or new philosophy of production (Lean Production) is going to help the chaotic situation in the construction industry.

2. Aim of project

The aim of this document is to explain the traditional construction industry and changing atmosphere of industry. Whilst the problems, which are causing the failure of the projects, nowadays in the construction industry. We are going to study, how we can deal and solve these problems by new techniques of the modern world.

3. Problem statement

This document will specify the ongoing problems in the industry of construction nowadays, and will provide different tools and technique through which we can trim down these problems. This document will show the implementation of lean technique or lean philosophy to the industry of construction and it will also explain the outcomes from this technique. The main questions of this document are as follows:

1. Which competences and demeanors are significant among project managers, and is effective implementation of lean techniques are attainable in construction projects?
2. What steps should be taken to reduce the cost, waste, improve quality, and to provide a trustable and working atmosphere for the workers.
3. What obstacles have to be abridged to improve the operations, and should be beneficial for the project.
4. What are the reasons that traditional project management philosophy is obsolete nowadays?
5. How can lean techniques help the construction industry to improve their situation?
6. How Last Planner System (LPS) is helping to improve the production in the construction industry?

4. Project limitations

Many researchers have worked a lot to solve these problems in the construction industry and to make it more competitive in the market. Many methods have been introduced for example partnering, TFV production (transformation, flow, and value stream), lean technique, bygLOK, bygSOL (Danish experimental project) and many more.

In this document, the focus of the study is on implementing the lean technique or lean production philosophy to the existing problems in the construction industry. In this report, we are going to implement Last Planner System, which is one of the important tools of the lean tools, and its effects and achievements.

5. Methodology

I read books from the library which were available in the university library. Meanwhile, I surfed on the internet to find the articles concerning lean production. A lot of work is done on lean production, which helped me a lot.

I found some interesting case studies, which I wanted to add to my thesis. I read few case studies and I selected two of them. I read them carefully and wrote them in my thesis with my own words.

6. Theoretical background

6.1. Introduction to construction industry

What is the construction industry? It is a spacious notion that comprises many diverse players such as manufactures of raw material and semi-manufactured materials, retail dealers, transport companies, consultants, general contractors and the sub contractors. The manufacturers of material and their vendors often have customers not only from construction industry but also from others, such as automotive industries, shipyards, paper mills, and the chemical industries. It is therefore intricate to make a discrete
definition of the construction industry. Construction industry plays an important role in
economy of any country and it provides many jobs for more than million of peoples, and
myriad more in industries whose fates depend on construction activities. And as much it
is important, same as it is uncertain and complex.

During recent decades there has been a swift increase in the cost of housing in Sweden.
Many have blamed construction industry and made this industry responsible for this rapid
increase in cost. Whilst, cost of housing, isn’t the thing commonly hashed out in Sweden
during recent decades. Many other aspects of construction have been discussed such as
high unemployment rates, lack of skilled workers, quality, low investment in R&D, high
production costs, low productivity, lack of dwellings, surplus of dwellings, subsides and
governmental spending in large infrastructure projects[13].

If we look for the definition of complexity in projects, at present there is no agreed
definition, no single theory, and most probably will never have. It has been recently
realized by the project managers in different projects. Researchers are working on this
area but still it is considered to be a poor area. Different peoples have different opinions
to explain the word complexity, but it is making it more complex and considered to be a
real problem, especially for organizational projects. The reason for this is that in
organizational projects, the interaction among various stakeholder groups and investors
are on high degrees [8].

However, construction industry is in a transition. Many changes are happening which
weren’t common in last few decades. These changes are supposed to happen because of
new technologies and competitive nature of the global market. Like so many other
businesses and institutions, this century holds untold opportunities and challenges and,
for the wary, several detours along the way. Many of the trends that developed in last
decades of the twentieth century, such as industry consolidation and intrusion of foreign-
based construction companies seeking the relatively safe haven of world markets, haven’t
only continued but appear to be accelerating. [5]

6.1.1. Developing Trends in This New Millennium:

The first decade of the new century made it very obvious that, changes should happen in
the industry of the construction, to be competitive and be in the long run of the modern’s
world market. Both institutional and resource changes are taking place that will affect all
facets of the industry:

- Human resources
- The organization
- Project delivery systems
- Technology
- Quality control
- Safety
- Productivity
- Dispute resolution procedures

**Human resources: The Workforce**

In 1980’s construction industry began to realize the growing shortage of skilled workers and experienced managers. Nowadays it has reached to dangerously low level in today’s marketplace and it remains one of the major challenges facing the industry. Signing bonuses, once relegated to professional athletes, are now prevalent in many areas of the country and reveal the desperation of some contractors in their quest to attract productive employees. One of the major challenges of this century will be to recruit and train the new comers and new talent to the construction industry, a task that is really needed and urgent to the interest of the country.

The demographics of population had already warned the construction industry several decades ago but unluckily it was not taken gravely. According to the demographics of population, by 2010 it is forecasted that older males in the age of 55 to 64 year will outnumber the young guys between 18 to 24 years by 1.5 million at least. In year 2010, older males ranging from 55 to 64 will get increase from 10 million to 17 million. It is so obvious that in future there will be a shortage of new talent and innovation, which is really needed by the construction industry.

**The Organization**

The globalization has brought a lot of changes and left its mark on the building business as well. The long term stability and growth of the construction industry has been recognized by welcoming the builders and investors all over the world. For example, United Kingdom, Sweden, Germany, France, Japan, and the Netherlands secured a 24.3 percent share of USA domestic market construction business in 1999; and this takes into account only $1.46 billion of the $4.7 billion Turner construction volume achieved in that year when it was brought up by Germany’s Hochtief A.G. construction company. For example, the international companies like, Skanska, Bovis lend Lease, Hochtief, Phillip Holzman, Bouygues, Kvaerner, AMEC, Balfour, Kajima, and Bilfinger+ Berger Brau, were, and are still continuing to be active in the U.S. domestic construction scene.

During last ten years or so, the concept of consolidation has been occurring among the contractors. This trend began in the mid-1990 accelerated by 1998, as few investors groups began to buy up hundreds of subcontracting firms, assuming that consolidation could bring increased profit due to economies of scale and increased geographic area operations. Some mechanical and electrical subcontracting firms noticed increase in sales volume by $3 billion due to consolidation. It was a particular field where subcontractors had reported 27 percent of yearly sales less than $250,000.
Technology

The construction industry has been lagging behind and has many problems as compared to last few decades. But this is not the situation nowadays, new technologies has been introduced in the industry of construction e.g. computers, many other software’s for designing engineers, digital cameras at job site which record daily images of the construction site, due to which its very easy to explain the situation of the site to the customer specially when work at site stop due to bad weather (rain, flood etc) or some earthquake etc. Similarly CD’s are replacing big and huge cardboard boxes for project archival documentation, and Nextel is helping with jobsite communication. Number of software’s has been introduced in the field of project management, which led to variety of hardware and software selection.

Project Delivery Systems

Due to the competitive nature of the construction industry, companies adopted Fast-track construction, to compress the time and to increase the rate of production on the site. But on the other hand the technique of time compressed jobs increased a lot of work for workers and in offices too, which wasn’t easy to handle. Trust has been build and taken by the design-build process not only in private sector but in public sector as well. But due to fast-track construction a lot of misunderstandings and problems takes place, which leads to disputes and conflicts.

Quality Control

Due to the shortage of skilled workers and experienced managers, it is now very important to increase the productivity and to reduce the errors, rework and call-backs. Whilst, due to the competitive nature of construction market, if some company aren’t able to produce “quality products”, soon they will be out of the market, because many more are waiting in a queue to replace the existing company.

The International Organization for Standardization (ISO), with a headquarters in Geneva, Switzerland, has established two generic standards for construction industry all over the world, to control over quality in construction. Firstly, ISO Standard 9000 applies to quality management system and secondly, ISO Standard 14000 deals with environmental management systems. The main objective of ISO in the design and construction field is to ease the global exchange standards and to have control on the trade of goods and services.

Safety

The working environment will only be safe, if the workers are experienced and skillful. The deficiency of skillful managers and workers are the reason for not having good safety at the construction site. Many customers also ask for the history of safe working during the bidding of the project, to know the background of the company with whom customer is going to have business.
Productivity

Due to the lack or scarcity of skill workers and managers, contractors are reporting about delaying of work. And similarly, it is also bringing adverse effects on the rate of productivity. Contractors are complaining about the time consumption by the workers as compared to, when they had skilled workers. That’s why experienced managers have been asked to have more responsibilities on their shoulders. But due to the implementation of the new techniques and tools, they have controlled the rate of productivity in the construction industry.

In the construction industry almost 85 to 95 percent of the budget, get consumed in the field operation. And if there is some quality or safety problem on site, the budget will get excel and will create a lot of problems. To overcome this problem, industries really need skill workers and managers, to overcome through these problems, improve the productivity and to achieve acceptable quality levels.

Dispute Resolution

In the construction industry, companies work together, companies can be from any part of the world. The nature of the projects in construction industry is temporary, which creates a lot of problems. Some workers don’t put there all energy, don’t co-operate with working teams and with each other, because they know that they are working together only on this project and don’t know when they are going to work together again. This is the reason that, need of construction litigation has been felt. Construction litigation has been used to solve the problems and to seek for more rapid solution.

In the evolution of the construction, partnering also played an important role. In partnering many companies and agencies work together. To keep these companies and agencies together, and to resolve disputes, construction industry made dispute very visible and try to look for its solution. It was appreciated all over the world when American Institute of Architects revised their A201 document, General Conditions to the contract for Construction. This document helps to resolve disputes and disagreements among different companies and agencies.

The changing Marketplace

In this modern world, changes have to be taken place, other wise companies; those are still using traditional way of techniques or tools, will be soon out of the market. Similarly in the future, managers have to be very smart, and very specialized. To be successful and competitive in the market, companies have to be very careful and keen about the strategies and tools that can be used in coming year of the competition.
The Changing Role of the General Contractor

In fifty years, the role and character of the general contractor have changed dramatically. The time has gone when general contractor employed crews of laborers, carpenters, operating engineers, masons and significant number of excavating equipment performing substantial amount of work by their own free will. As compared to last few decades, the construction industry is much more sophisticated in design and the contractors are very familiar to the changes and its not new thing for them.

In coming years, a lot of more problems, important issues, and thoughts will be on top list, instead of over cost and time schedule. Contractors have to adopted and embrace the advantages of the electronic age other wise they will loose the long run of market competition. The old concepts and thoughts have to be replaced by new concept and innovations.

The Project Manager’s Role

The role of project manager’s is really important in construction industry. The project manager is responsible for many things but the main issues are time, cost and quality.

Construction project management can divided into four main components, which are as follows.

1- **Construction engineering**. It is about the proper technique of assembling components, material, equipment, different systems, and best utilization of construction technology.

2- **Management of the construction process**. It provides the best way to implement the processes of construction e.g. time scheduling, control of the flow of labors, materials, quality and safety etc. on construction site.

3- **Human resources management**. Labors are playing an important role in any kind of a project. Labor productivity, and maintaining good environment for workers to work together, is important factors to make project “successful”.

4- **Financial management**. The nature of construction industry is very complicated and uncertain. And historically the margin of getting profit has been also low. This part of management is responsible for control over costs, cash flow, and project funding. Whilst, it gives a nice view to stakeholders and investors for future business.

There are seven important criteria’s, which project manager should not forget, for completion of projects and to make it successful.

1. The project was completed on time.
2. The complete project cost remained within budget.
3. The quality levels expected were achieved.
4. The project has been completed, without leaving unsolved disputes and claims.
5. The contractor maintained a professional relation with the designers.
6. The contractor had a nice and beneficial relationship with all subcontractors and vendors.
7. The relation between contractor and client was the very good.

The role of project manager changes from project to project and varies in different situation. In some projects, project managers are responsible for many other issues which have never been their responsibility. In short, project management means, management of projects. Project manager can play many important roles in different shapes, in different situation, to make and finish project successfully [5].

6.1.2. Construction Processes

Figure 1: Project management and design process.

In following, the processes are explained as shown in fig-1[12].

Formulation

Formulation is the beginning or start of the project. It consists of identification of scope, budget and schedule for the planned project. Usually scope is identified and discussed between customer and the project manager. After that, sketch is made by the project manager and handled to the project team. After identification of scope, project manager appraises the plan, estimates the total cost of project and time schedule for project. The scope, schedule, and cost information is summed up in a letter form and sent to the client or customer. If the customer is happy with sent information, he will concern to his team or business manager. When it gets confirmed, customer will accept their offer and project will be placed in a queue. It will be signed to available project manager or skilled project manager in case of difficult project.

After assigning the project, project manager is supposed to read the whole project very thoroughly and make himself familiar with the project by retrospection of formulation file. Whilst, project manager should begin to prepare the approval paperwork that should go to pertinent approval bodies. Similarly, project manager should also work on work plan, which have to be handed over to project team.
Preliminary Design

This stage of construction process is composed of following elements;

Overview

First phase of design process is preliminary design. Project manager will arrange meetings with Design Team to collect the information. The responsibility of Design Team is to investigate the field and look for the problems, impact of the project and questions to be answered. Blueprints of the project get prepared by Design Team that will be reviewed by all stakeholders and will be rectified later. This stage of project specifies the parameters and arrays of project.

Scope

Scope of the project is defined during the formulation process. Meanwhile, project manager will arrange meetings with Design Team, to make the scope of project crystallized. Any changes in project scope must be approved by the project manager with all outcomes from the planned schedule, budget and time.

Schedule

The time schedule of each project is defined during process of formulation. Project manager will decide the schedule for project when project is authorized to begin. Impacts of changes in time schedule will be supervised all the way in design phase and will be partaken will all parties. Any changes in project schedule must be approved by the project manager with all outcomes from the planned schedule, budget and time.

Budget

The giben budget of each project is defined during process of formulation. Project manager will further rectify the budget, when project is authorized to begin. The main concern of project manager will be that budget shouldn’t increase from planned budget. The encroachment of budget will be supervised all the way through design phase. As time schedule and scope of project will affect budget, an appraisal will be prepared at the end of each Design Phase, so that project should remain in planned budget.

Approvals

Project manager will prepare papers for the approval of its specified scope, schedule and planned budget. These papers will be sent to customer to confirm that the project is in approved parameters. Project manager cannot change the scope or budget of the project which is stated in the approval for the project.
Roles and Responsibilities

The best way to make project successful is to work as a combined team. The responsibility of team is to espouse the scope, schedule and budget and keep these different parameters while taking decision. Design Team must harmonize with different groups or teams to attain the triumphant project. Every team can communicate freely with each other but minutes of meeting and memos should be sent to project manager. Project manager should be clued-up thoroughly of every facet of the project, because project manager is the main character of the project and all the questions will be conducted from project manager regarding the project performance.

Meetings

The project manager will hold meetings on regular basis. All players of the project should have opportunity to share their ideas about the forthcoming phase and time period of work. During meetings, focal point will be reviewing the scope, schedule and budget of the project. Whilst, design team will provide a summary of their work and will depict how entropy will be accumulated and depicted into design. All the memos and minutes of meeting will be sent to the project manager, because he should have knowledge about all information flow in the project and among the team members.

End of Phase Review

It is significant to impart the closure at the end of each phase of the project to reevaluate the status of schedule, scope and budget. After closing of each phase, documents are passed on and distributed to suitable parties for review. Parties will send comments on it and design team will reply to the remarks with no delay. The project should not carry on to next phase if the scope, schedule and budget aren’t circumscribes of the project.

Equipment Issues

There are always problems concerning new and existing tools. To cope with this problem, Design Team will use daggers to label all existing equipment and distinguish it with unique denomination. This will make easy the movement of equipments to the site, and the kind of tool to be used in a specific area. Proper record will help to distinguish the responsible person for palming, storage and purchase of each piece of equipment.

Design Development

Overview

Design Development elucidates more in detail about agreed design of the project. This phase of the project is more passionate among the other phases of project. Customer also plays an active role in this phase, to make sure that all requirements are foregathered by design. All cardinal decisions are approved by the end of this phase.
Scope

The project manager and his team will work with design team throughout the design development phase to keep the scope of the project aligned with initial endorsement. Any changes in the project scope must be approved by the project manager with all outcomes from the planned schedule, budget and time.

Schedule

The affects of schedule will be supervised throughout the design development phase and will be partaken with all parties. Any changes in the project schedule must be approved by the project manager with all outcomes from the planned schedule, budget and time.

Budget

The main concern of the project manager will be that budget shouldn’t increase from planned budget. The encroachment of the budget will be supervised all the way through design development phase. As the time schedule and scope of project will affect budget, an appraisal will be prepared at the end of each design development phase, so that project should remain in the planned budget.

Roles and Responsibilities

The best way to make project successful is to work as a combined team. The responsibility of the team is to espouse the scope, schedule, and budget. The management team should keep these different parameters while taking decision. The design team must harmonize with different groups or teams to attain the triumphant project. Every team can communicate freely with each other but minutes of meeting and memos should be sent to the project manager. The project manager should be clued-up thoroughly of every facet of the project, because project manager is the main character of the project and all the questions will be conducted from project manager regarding the project performance.

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Moves

In the beginning of the construction, if the site (construction area) is occupied it is mandatory to move the residents out to a momentary locality. The locality must be recognized near the beginning of designing progression so that moves can be made early on, so construction can start as it is scheduled. All the expenses regarding the movement of residents to a locality will be accomplished by the project. The issue of movement should be decided in the beginning of project or signing the contract.

End of Phase Review

It is significant to impart the closure at the end of each phase of the project to reevaluate the status of schedule, scope and budget. After closing of each phase, documents are passed on and distributed to suitable parties for review. Parties will send comments on it and design team will reply to the remarks with no delay. Project should not carry on to next phase if the scope, schedule and budget aren’t circumscribes of project.

Equipment Procurement

The necessities of pertaining to equipment should be clearly recognized in the beginning of the project. There will be updated information document in the phase of design development. This document will help to note the changes in schedule of equipments, which will shun confusion and complications concerning accessible equipment.

Construction Documents

Overview

During design development, construction documents developed and nailed down the design of the project. The core importance of this phase is to substantiate that all information is in drawings and in the specification. The transparency and comprehensiveness is the most important factors to evade costly changes during construction.

Scope

The scope of the project must be cohered with agreed construction documents. The project manager will work with his project teams to keep the scope in sequence with preliminary endorsement. Any alterations to the decided scope of the project must be permitted by the project manager with all upshots for the schedule and budget empathized by funding source of project.
Schedule

The affects of the schedule will be supervised throughout the design development phase and will be partaken with all parties. Any changes in the project schedule must be approved by the project manager with all outcomes from the planned schedule, budget and time.

Budget

The main concern of the project manager will be budget, which shouldn’t increase from planned budget. The encroachment of the budget will be supervised all the way through design development phase. As the time schedule and scope of project will affect budget, an appraisal will be prepared at the end of each design development phase, so that project should remain in planned budget.

Roles and Responsibilities

The best way to make the project successful is to work as a combined team. The responsibility of team is to espouse the scope, schedule and budget and keep these different parameters while taking decision. The design team must harmonize with the different groups or teams to attain the triumphant project. Every team can communicate freely with each other but minutes of meeting and memos should be sent to project manager. Project manager should be clued-up thoroughly of every facet of the project, because project manager is the main character of the project and all the questions will be conducted from project manager regarding the project performance.

Meetings

As compared to other phases, there are fewer meetings in Construction Documentation phase.

End of Phase Review

It is significant to impart the closure at the end of each phase of the project to reevaluate the status of schedule, scope and budget. After closing of each phase, documents are passed on and distributed to suitable parties for review. Parties will send comments on it and design team will reply to the remarks with no delay. Project should not carry on to next phase if the scope, schedule and budget aren’t circumscribes of project.

Early Demolition

Early demolition is conceded as a pre release of construction so that the Design Team can more plainly recognize conditions of field. Use of early demolition is that, it discovers expected problems early so that can be dealt during the design phase, not during the construction phase, when all changes are lavish and affect schedule.
Construction

Overview

The phase of construction postulates the accomplishment of the project as it is delineated in Contract Documents e.g. construction drawings and specifications. Contract will be pioneered between project manager and constructor, based upon an agreed monetary value for the work.

Scope

The scope of the project must be cohered with agreed construction documents. The project manager will work with his project teams to keep the scope in sequence with preliminary endorsement. Any alterations to the decided scope of the project must be permitted by the project manager with all upshots for schedule and budget empathized by funding source of project.

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The affects of schedule will be supervised throughout the Design Development phase and will be partaken with all parties. Any changes in project schedule must be approved by the project manager with all outcomes from the planned schedule, budget and time.

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The main concern of the project manager will be that budget shouldn’t increase from planned budget. The encroachment of budget will be supervised all the way through Design Development phase. As time schedule and scope of project will affect budget, an appraisal will be prepared at the end of each design development Phase, so that project should remain in planned budget.

Roles and Responsibilities

The best way to make project successful is to work as a combined team. The responsibility of team is to espouse the scope, schedule and budget and keep these different parameters while taking decision. The design team must harmonize with different groups or teams to attain the triumphant project. Every team can communicate freely with each other but minutes of meeting and memos should be sent to project manager. The project manager should be clued-up thoroughly of every facet of the project, because project manager is the main character of the project and all the questions will be conducted from project manager regarding the project performance.
Meetings

Meetings play an important role during the phase of construction. Progression of the construction and many issues bob up during this phase. The meetings are usually held after each 2 weeks. The following docket objects are discussed:

- Schedule of values
- Entries list and log
- Enfranchisement of insurance
- Bid list
- Security identity
- Larceny bar
- Parking
- Keys
- Field phone
- Safety plan
- Safety cleats
- Shutdown notification
- Hot work
- Construction hours
- Weekend work
- Contiguousness fracas
- No foul language
- Sexual harassment
- Use of lavatory amenities
- Material storage
- Dumpsters
- Dust control
- Deliveries
- Job meetings
- Pay application
- Changes in work
- Equipment procurable and relocation
- Record drawings
- Closeout
- Signage

Moves

In the beginning of the construction, if the site (construction area) is occupied it is mandatory to move the residents out to a momentary locality. The locality must be recognized near the beginning of designing progression so that moves can be made early on, so construction can start as it is scheduled. All the expenses regarding the movement of residents to a locality will be accomplished by the project. The issue of movement should be decided in beginning on project or signing the contract.
Notifications

The project manager and the construction team are responsible for notification of imminent activities or to prohibited areas, where there is risk of any calamity.

Hazardous Material Testing and Removal

The project manager will commence a perilous material inspection of the construction site. The inspection is usually held by Office of Environmental Health and Safety. If perilous materials are revealed, they can be removed and can be made safe place to work.

Substantial Completion

The substantial completion is an important day of any project. A certificate of substantial completion is usually prepared by architect, and responsible for seizing a punchlist. Punchlist represents those items which haven’t been completed at the date of completion but allocated in contract. The main concern of punchlist must be the task which haven’t been completed but allocated in contract. It has no thing to bring change in scope of the project.

Occupancy

After substantial completion of project, possession can take place at any time. The date for possession will be scheduled in project agenda.

Construction Closeout

Overview

The construction closeout will happen after the completion of punchlist items, which have not been completed before.

Punchlist

Punchlist is a catalog of the tasks which have been settled in contract but still haven’t finished. The main concern of the punchlist must be the task which haven’t been completed but allocated in contract. It has no thing to bring change in scope of the project.

Assignment Plans

It is a document, which contemplates the architectural stratum of the contract documents. This document is composed of architectural layout, room name and its dimensions etc [12].
6.2. Project Management

The Project Management Institute (PMI) has introduced a lexicon, which can help project managers in their daily life. This lexicon called as “A Guide to the Project Management Body of Knowledge (PMBOK Guide)”, published in 1996. All the project managers are supposed to have a good knowledge about this lexicon while working with different project. It is an exclusive term that describes the sum of knowledge with in the profession of project management.

6.2.1. PMBOK Guide

The aims of this guide book are as follows [3].

- Add new material reflecting the growth of the knowledge and practices in the field of project management by capturing those practices, tools, techniques, and other relevant techniques, and other relevant items that have become generally accepted. (Generally accepted means being applicable to most projects most of the time and having widespread consensus about their value and usefulness.)
- Add clarification to text and figures to make this book more beneficial to users.
- Correct existing errors in the predecessor document.

The purpose of this book is to identify and describe that subset of the PMBOK that is generally accepted. Generally accepted means that the knowledge areas and practices mentioned and described in book are mostly applicable to most projects at most of the time. And one of the other reasons is to provide a common lexicon within the profession and practice.

6.2.1.1. The Project Management Knowledge Areas

A Guide to the Project Management Body of Knowledge (PMBOK Guide) consists of 9 core processes, which is mentioned in the following figure.
6.2.1.1.1. Project Integration Management

The project integration management includes the processes required to ensure that different elements of the project are properly working and co-coordinated. It involves meeting or exceeding the needs and expectations of the stakeholder.

6.2.1.1.2. Project Scope Management

Project scope management includes the processes required to assure that the project includes all the work required, only work required by customer (as in contract), to complete project successfully. Purpose of this process is mainly to be precise, what has been asked by the customer.

6.2.1.1.3. Project Time Management

Project time management includes the processes required to assure the completion of the project “on time”. This process revolves around the deadline of the project, when project should be finished and handled to customer.

6.2.1.1.4 Project Cost Management

Project Cost management includes the processes required to ensure that project is completed with the approved budget. The main concern of this process is to have check on budget and not to get over-budgeted.
6.2.1.1.5. Project Quality Management

Project quality management includes the processes required to ensure that the project will fulfill the needs and according to standards as it was in contract.

6.2.1.1.6. Project Human Resource Management

Project human resource management includes the processes required to ensure the most effective and efficient use of the people and skilled workers involved in the project.

6.2.1.1.7. Project Communication Management

Project communication management includes the processes to ensure the proper, timely generation, collection, dissemination, storage and finally disposition of project information. It provides the actual state of the going project, either it is on right track or going to fail.

6.2.1.1.8. Project Risk Management

Project risk management includes the processes to ensure and identify, analyze, and responding to risks in project. It includes the probability of risk occurrence and its consequences towards the project.

6.2.2. What is Project Management?

To understand the meaning of the project management, we can split it into i) project and ii) management.

Defining “project”, you will find multifariousness definitions on “what project is? One of the gurus of project management describes a project as an execution of certain tasks within certain specifications with defined starting and finishing dates, funding limits and which takes in resources e.g. money, people and equipment etc. The definition in A Guide to Project Management is “a unique set of coordinated activities, with definite starting and finishing points, undertaken by an individual or organization to meet specific objectives within defined schedule, cost and performance parameters”. The Gower Handbook of Project Management defined it as “a project is a cycle of activities with the purpose of supplying, within definite start and completion dates, a unique product, service or set of information to a specified quality and cost”. Followed by PMI’s Guide to the Project Management Body of Knowledge—PMBOK –defines project as “a temporary endeavor undertaken to create a unique product or service” [4].

These definitions almost explained the word “project”, but hardly mentioned the most fundamental characteristic of the project, which is a direct result of this uniqueness called life cycle. The only thing which distinguish project from non-project is “life cycle”,

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doesn’t matter on complexity of a project. The unchanged sequence of life cycle is mentioned in following figure-3.

![Figure 3: The project life cycle. [4]](image)

Management is an activity. It is the activity of planning, coordinating, conducting and controlling, communicating, deciding, and using resources wisely etc. In other words of the leading management thinker, Peter Drucker, “it is a practice not a science. It is not knowledge but performance”.

As project life cycle distinguish project from non-project, similarly the only thing which distinguish project management from other forms of management are the management skills and actions through out the life cycle of the project. The discipline of the project management varies depending upon the nature of the project, the role of the project manager and depends on the stage of project at which project management is operating.

Basically project management involves some combination of processes i.e. scope management, time management, cost management, and human resource management. The important aspect of management is to keep people together, including communication, leadership skills and team working. Similarly in any project, you have to deal with different issues e.g. issue of strategy, finance, organization, technology, control, people and culture, commerce and contracts, community and environment, process and timing etc. Project manager should be aware of these issues in a project and have to manage them in an appropriate way. Some time project manager will not feel to be expert in these issues and may be have a lack of time, and may have difficulty to work with these issues alone. The job of the project manager is to integrate all these issues efficiently and to meet the objectives of the project.

The project management taught by most of the textbooks on project management, many of business school, and institute of project management itself, is to accomplish the project on time, in budget, and to scope. Project management seems to be not covering the project definitions, and especially with technology, environment and commercial issues. As a matter of fact since 1960, a little advancement has been shown about the theory of project management. [8]

According to PMI’s PMBOK (guide book for project manager), project manager should know the nine knowledge areas i.e. integration, scope, time, cost, risk, quality, human
resource, communication and procurement. These knowledge areas are shown in figure-4.

Figure 4: The project management institute’s nine major knowledge areas. [4]

History tells us that by deploying these project management areas alone, give us no guarantee or assurance of completion or accomplishment of the projects on time, in budget and to scope. For example, Oxford University and USA in the 1980’s carried out a research, which showed that many of the factors which causes failure of projects aren’t mentioned or not covered by the PMBOK. The research showed and pointed out the factors which played an important role in the failure of projects were client driven changed specification or order quantities, technology problem, poor design management, external price changes, environmentalist or community, political difficulties, geotechnical problems, weather and labor problems. Till today these factors are missing from the literature of project management. Material provided by PMBOK is encouraging in managing projects but not exactly sufficient enough to manage the project successfully.

Due to the failure of theory of project management, the main domain for the essence of the project management research at UMIST, in developing the 4\textsuperscript{th} edition of the Association for Project Management’s Body of Knowledge (APM) in 1998-99. The project management view of APM is considered to be broader than PMI’s PMBOK [4].
6.2.3. Theory of Project Management

The project management and all kind of productions have three kinds of goals, which are i) the goal of getting intended products produced in general, ii) internal goals (cost minimization, level of utilization etc), iii) external goals (needs of customer e.g. quality, dependability and flexibility).

The PMI’s PMBOK Guide states that projects are composed of two processes i.e. project management process and product-oriented process. The project management processes are further divided into initiating, planning, execution, controlling, and closing process. But the core processes of “theory of management” are processes of planning, execution, and controlling.

| Theory of project | Conceptualization: Project is a transformation of inputs to outputs  
| **Principles:** | 1. The total transformation of a project can be decomposed into manageable and well-understood sub-transformations, tasks  
| 2. A project can be realized in an optimal manner by realizing each task in an optimal manner and the tasks in optimal sequence  
| Corollary: Project performance can be improved by improving the tasks  
| Assumptions: | 1. Tasks are independent, except sequential relationships  
| 2. Tasks are discrete and bounded  
| 3. Uncertainty as to requirements and tasks is low  
| 4. All work is captured by top-down decomposition of the total transformation  
| 5. Requirements exist at the outset and they can be decomposed along with work |

| Theory of management | Theory of planning | Conceptualization: There is a managerial part and an effector part in the project; the primary function of the managerial part is planning, and the primary function of the effector part is to translate the resultant plan into action.  
| **Principles:** | 1. Knowing the current state of the world, the desired goal state, and the allowable transformations of state that can be achieved by actions, a series of actions, the plan, can be deduced.  
| 2. The plan is translated into reality by the effector part of the organization.  
| **Assumptions:** | 1. Translating a plan into action is a simple process, by following directions.  
| 2. The internal planning of a task is a matter of the person to whom the task has been assigned.  

| Theory of execution | Conceptualization: Managerially, execution is about dispatching tasks to work stations.  
| **Principle:** | When, according to the plan, the time has arrived to begin task execution, it is authorized to start, in speech or in writing.  
| **Assumptions:** | 1. The inputs to the task and the resources to execute it are ready at the time of authorization.  
| 2. The task is fully understood, started and completed according to the plan once authorized. |
**Conceptualization:** There is a process to be controlled, a unit for performance measurement, a standard for performance and a controlling unit (thermostat control).

**Principle:** The possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached.

**Assumptions:**
1. The process is of continuous flow type, the performance of which is measured at aggregate terms
2. The process can easily be corrected by the control available.

<table>
<thead>
<tr>
<th>Theory of control</th>
<th>Conceptualization: There is a process to be controlled, a unit for performance measurement, a standard of performance and a controlling unit (thermostat control). Principle: The possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached. Assumptions: 1. The process is of continuous flow type, the performance of which is measured at aggregate terms 2. The process can easily be corrected by the control available.</th>
</tr>
</thead>
</table>

**Table 1: The underlying theories and assumptions of the project management.** [10]

First we are going to concentrate on theory of project, theory of management, followed by the core processes of planning, execution and controlling.

**6.2.3.1. Theory of Project**

Scope management is considered to be the important process of project management. Scope management is the agreed amount of work to be done, and scope of the project is defined with the help of Work Break down Structure (WBS). Project management is about managing work, secondly that total work can be decomposed into smaller chunks of work. In PMBOK Guide these chunks are called as *activities*. PMBOK Guide reveals that project management is mainly dependent on core processes i.e. scope management, time management, and cost management. The main concerns of project management approach are, to consider what needs to be done, who is going to do which task, at what time actions have to be done, how much budget have to be spent, and how much time is going to be spent. Work Break down Structure can play an important role regarding these issues. [9]

**6.2.3.2. Theory of Management**

The PMI’s PMBOK Guide divides the project management processes into initiating, planning, execution, controlling and closing process. But we are going to concentrate on basic three core processes i.e. planning, execution and controlling. These processes form a close loop, which is mentioned in figure-5.
The theory of management is based on three theories, i.e. management-as-planning (theory of planning), the dispatching model (theory of execution), and thermostat model (theory of control). Basically, management-as-planning is consisting of creation, revision and implementation of plans. Connection between actions of management and outcomes of the organization is the main focus on this theory. Dispatching model tell us about planned tasks, that it can be executed by informing the executor at the start of any task. Thermostat model is composed of following elements:

- Standard of performance
- Measurement of performance at output.
- The variation between measured value and standard is helpful for correcting the process and to achieve the standard [10].

6.2.3.2.1. Theory of planning

The planning of projects is thoroughly described in PMBOK, under different knowledge areas. Further planning process is composed of core processes and facilitating processes. There are 10 important core processes of planning process according to PMBOK Guide and i.e. scope planning, scope definition, activity definition, resource planning, activity sequencing, activity duration estimating, cost estimating, schedule development, cost budgeting and project plan development.
PMBOK Guide is very much dominated by planning processes. There are ten planning processes but only one executing and two controlling processes. More importance is given to planning as compared to the executing [9].

6.2.3.2.2. Theory of execution

The view of project plan execution is very blurry in PMBOK Guide and has not been explained very clearly. The only way to differentiate between plan work and work done is with regard to work authorization system. A work authorization system is recognized procedure for conforming that work is done at right time and in a correct succession.

The concept of job dispatching in manufacturing and the underlying theory of execution look similar, where work and plan get overlapped on each other. Job dispatching according to modern definition is a procedure to execute a certain task on a machine that just come available. Many decisions are normally carried out in planning phase of the project. [9]

6.2.3.2.3. Theory of Controlling

According to PMBOK Guide, core processes of controlling have been divided into two sub-processes: performance reporting and change control. According to performance reporting, corrections are approved for executing processes and meanwhile, changes are approved for the planning process.

Performance reporting leads to thermostat model or model of management control consists of the following elements, which are stated below.

- There is a standard of performance
- Performance is measured at the output (or input)
- The possible variance between the standard and the measured value is used for correcting the process so that the standard can be reached [9].
6.2.4. Anomalies

Still constructions industry is facing many failures and having problems to finish the project in time. Many scholars and researchers worked on this issue and concluded that, the underlying theory of project management isn’t empirically valid. The different limitations in theories of project management are explained below.

6.2.4.1. Theory of Project

The theory of project is mainly based on transformation, and there is no concept of flow processes during project. And this is one of the reasons that there is a lot of rework in projects. Effects of these revisions, reworks and repairs on big projects can be very significant. Individual impact of these reworks will be very small, but overall it cost a lot of money and waste of time. [9].

6.2.4.2. Theory of Management

6.2.4.2.1. Theory of planning

It is very difficult to maintain up-to-date schedule, practically in any project. The reason behind it is that, a lot of changes happen during the execution of the project. Planning in construction is not an easy job at all, because of its turbulent or unsteady nature. First, the motivation of planning can come from customer side according to his requirements. Secondly, the key inspiration and motivation for planning is normally controlled and organized as compared to than execution. Thirdly, the most important problem is to separate execution from planning. Planning has just become an explanation for different tasks rather than what has happened. The role of planning is being ignore all the time, many tasks get executed before and many get late but not according to the planning of project. [6]

6.2.4.2.2. Theory of execution

The realization rate found for weekly tasks in conventionally managed construction were 50—60 %. This low rate is just because of missing inputs or resources during the execution of task. Observation has been made that execution must depend on informal management in order to succeed (contracts, plans, approvals etc [6]), according to management-as-planning. The underlying theory is managing the execution very informally [9].

It has been found that, the theory of execution has been ignored often in many projects. Report on Elimination of Waste in Industry writes that normally subcontractors have no calendar to know the dates for execution of different tasks, apart from starting and finishing dates for tasks. The deliveries of material is just controlled and shaped by only visiting working site some time.
6.2.4.2.3. Theory of Control

According to PMBOK Guide, theory of control is causing a lot of problems among the co-workers. Firstly, control induces explanation instead of correction. Validity of standards is usually challenged by supervisors in most of the cases. A lot of time (which means money) gets wasted just because of justification and making some one responsible for the problem, and mean while it also effects the working environment and relation among the co-workers.

Secondly, control leads to management of action. The managers usually try to decrease the actual cost to make cost variance positive. Similarly managers may also reduce the capacity to make performance better, but it may also cause overloading, due to which work flow will not be reliable.

Thirdly, collaboration gets ruins just because of this kind of controls. The budget may increase due to intense monitoring and which can also lead to stress among the workers. Whilst, it also effect the movement or transportation between activities, which can really affect the performance of the project. Schedules are just used for showing the successive relation between activates and similarly contracts gives right to owners and contractors to change the timing and succession of each activity.

Fourthly, performance can get affected by control. It have been strongly criticized that to believe that large projects can be measured by using yardsticks considered as simple addition of individual yardsticks of discipline, system and component. Revisions, repairs and reworks play a significant role and can really affect projects very much.

Fifthly, after detecting disagreements, it is not always true to get success in modifying the plan through control. It has been proved that in new product development projects, inappropriate schedule easily heads to premature decisions. [6]

6.2.3. APM Vs PMBOK

The Association for Project Management (APM) was formed more or less in 1988 and acquired PRINCE as their standard. PRINCE symbolizes Projects IN Controlled Environments. PRINCE was deduced from the standards, which were built up for Central Computer and Telecommunications Agency (CCTA). Later on, it got involved with the British government and additional organizations for updating PRINCE to PRINCE2. PRINCE2 is defended by the British government with participation of APM. Currently APM is using PRINCE2 as foundation for mandatory knowledge and certification examination. PRINCE2 is a five stage approach for modifying the control of resources and even the supervising of project right through the end. The APM offers four levels of certification, from Associate Project Management Professional (Level 1) to Certificated International Project Manager (CIPM) (Level 4) [22].
According to [22], here are the following certifications:

- Criteria: PRINCE2
- Certified International Project Manager (CIPM)
- Senior Project Manager (Level 3)
- Certified Project Manager (Level 2)
- Associated Project Management Professional (Level 1)

Figure-7 will glance through the APM BOK (4th Edition).

![APM BOK 4th Edition](image)

<table>
<thead>
<tr>
<th>APM BOK</th>
<th>PMBOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Project Management Framework</td>
<td>1. General</td>
</tr>
<tr>
<td>4. Project Integration</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>11. Project Management</td>
</tr>
<tr>
<td>10.3. Performance Reporting</td>
<td>20. Project Success Criteria</td>
</tr>
</tbody>
</table>

Comparison between APM BOK and PMI’s PMBOK is explained in figure-8 below.
<table>
<thead>
<tr>
<th>Included in</th>
<th>4. Project Integration Management</th>
<th>21. Strategy / Project Management Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>22. Value Management</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>25. Health, Safety and Environment</td>
<td></td>
</tr>
<tr>
<td>5. Project Scope Management</td>
<td>30. Work content and Scope Management</td>
<td></td>
</tr>
<tr>
<td>6. Project Time Management</td>
<td>31. Time Scheduling/Phasing</td>
<td></td>
</tr>
<tr>
<td>4. Project Integration Management</td>
<td>34. Change Management</td>
<td></td>
</tr>
<tr>
<td>10.3. Performance Reporting</td>
<td>35. Earned Value Management</td>
<td></td>
</tr>
<tr>
<td>Small section in 10.2 Tools and Techniques for Information Distribution</td>
<td>36. Information Management</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>40. Design, Implementation and Hand-over Management</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 8: Comparison of the PMI and APM BOK [4].**

It doesn’t only make the view of project management broader, but it also has revolutionary impact on relationship between performance and project objectives. APM is more concerned with project sponsors, owners or perspective. In this book the issue is not simply to accomplish the project on time, within budget, and to scope, but more concerned with the business to get success, to meet all requirements of customer and to keep eye on risks in the project while undertaking the project.

A lot of evolution and changes are needed to understand the concept of *delivering of successful project* in the traditional project management concept, and still a lot of work and research is needed to know the criteria for successful projects. Project management still has some pending questions and many researcher are still working and looking for answers of these question, and trying to know that will these theories will able us to make project successful. [4]

### 6.2.4. Current Issues in Project management

Here are few current issues, which are as follows.

- How can we make sure that our project develop and deliver successful products to the customer?
- How can we exactly fulfill the requirements and manage project development?
- How can we develop products more quickly (time-to-market, concurrent engineering) and securely (avoiding overruns and poor performance), and for better value (lower cost, better functionality)?
• How can we manage important issues like design, technology selection, documentation, marketing and testing etc.

• What is the best procurement strategy for our project, should we use partnering?
• Are we getting respectable productivity in our project life cycle
• What is the internet doing to project management practice? What is E project management, how will E commerce affect us and what is E learning?
• What kind of role should be played by the people in project management?
• Do we have correct and authentic project management processes and practices in our organization?
• How can our organization continuously learn and improve?
• How can we make it confirmed that current project management is giving promotion to our business.

And many more [7].

6.2.5. Successful Projects

Initiating and accomplishing projects successfully should be the main aim of the project manager. But the concept of success, as much it is important, at the same time it’s also very difficult. “Success is both an important concept and a difficult one. The Anatomy of Major Projects addressed the topic at length”.

The concept and definition of success of project is very blurry and difficult to understand. It depends upon your designation and your role in the project. The scope of the project should be very clear. The project manager should know the targets to achieve for customer satisfaction. Many of the reasons are not explained in the textbooks of project management, for instance PMBOK (e.g. technology, design, environment, and finance). And this is one of the reasons that projects are confronting with failures instead of success. Project management doesn’t only means simply completing task on time, in budget, and to scope. Project management really needs a more holistic model that can focus on success of any kind of projects.
Figure 9: Factors contributing in success and failure of projects [7].

Figure-9 shows an attempt to explain the factors, which really contributes towards the success and failure of project. This diagram explains that what it is that we are trying to achieve. The definition of success interacts with a number of key factors e.g. the sponsor’s objectives, the financing available, the socio-political, environmental context of the project, scheduling requirements and possibilities [7].

6.2.6. Leadership and Project management:

In conventional project management, authorization anticipates the future and depends on centralized planning, commencement of work, and thermostatic control by cutting across the standards. The leadership is obligatory to inspire and motivate the workers to achieve the required goals of project, and to conquer the problems and mishaps as they happen.

Henri Fayol, a French mining engineer, proposed that successful management required 5 basic functions, which are as follows:
1) To forecast and plan the future and to prepare plans of action
2) To organize the structure, people and material
3) To command activity
4) To coordinate, unify and harmonize effort
5) To control to assure policies and plans were followed

And similarly he identified 14 principles to be applied, which are as follows:
   1) Specialization-division of labor
   2) Authority with responsibilities
   3) Discipline
   4) Unity of command
   5) Unity of direction
   6) Sub-ordination of Individual Interests
   7) Remuneration
   8) Centralization
   9) Chain/ line of authority
  10) Order
  11) Equity
  12) Lifetime jobs (for good workers)
  13) Initiative
  14) Esprit de corps

These principles ascertain the nature and responsibility of leadership. The nature of work can be improved by focalization on labor and material. Motivation of workers is the main issue of the leadership.

Many think that a lot can be achieved through command and control leaders (according to Fayol’s principles), but it will always be full of risks. Similarly David Schmaltz is more direct, he says that we must all braze out the Master-Slave relationship from the classic project management.

Leadership is the skill to make the opportunity for successful and healthier future. The nature of leadership alters from concentrating on the obligatory objectives and the impulse to accomplish it. Leadership is responsible to create trust among the people and co-workers, manage action, learn, and innovate collectively. [14]

### 6.2.7. Introduction of the New Leadership

Triumphant teams of any project grounded on a foundation of conviction and trust. Trust gets developed when all workers and team members show a prototype of trustworthiness. Listening is the most important skill for leaders in this model. It includes listening for their ideas, requests, and to understand how can leader provide them an open platform for sharing their ideas. By developing trust, strangers can turn into friends and finally partners.
The new-fangled responsibility of every project manager is to provide a friendly and trust-worthy working atmosphere to workers, where they can expand their relatedness by mounting a shared understanding. Nowadays leadership bulges out, facilitates, and takes part in these kinds of conversations. Lacking of these conversations can really affect the assembly of peoples in any project. Customer really anticipate that the people working with project will make true their vision, be liable for enlightening and regulating it through the life of the project [14].

6.3. Production in Construction

Construction embraces a wide range of projects, which includes from sluggish, definite, and uncomplicated projects on one end and swift, tentative, and intricate projects on the other end. Luari Koskela lists differentiating characteristics of production in construction industry as one-of-a-kind nature of projects, site production, and temporary multi-organization.

The main discrepancy between manufacturing and production in construction is site production. Manufacturing in construction is fixed position manufacturing and they are ingrained in place. In construction, manufacturing takes place on one place and parts get accumulated on fixed position. The components become too hefty that they cannot be moved to assembly stations, as it happens in manufacturing, for instance manufacturing of ships or airplanes. The ingrained manufacturing in construction contributes to ambiguity and differentiation. For example, the condition of soil may fluctuate and vary extensively place to place and usually difficult to conclude exactly. Similarly the wind loads and seismic circumstances also differ from place to place.

In conventional production management in the construction, master schedule is practiced for plans of more unambiguous nature, like purchasing and short term plans. However, the untrustworthy nature of the construction made the concept of master schedule outdated. Whilst, updating of master schedule is normally lacking in the construction industry, and similarly short term is mainly imparted to the foreman or teams on the construction site.

In the following, we will describe a production philosophy and will bang on to the examination of traditional production philosophy. After noticing certain flaws in conventional concept, the vital elements of new production philosophy are demonstrated [16].

6.3.1. What is a production philosophy?

The answer of this question has been looked by many researchers, but didn’t found any satisfactory definition of production. As Bloch mentioned that, lack of definition may be connected with the fact that there is no science of manufacturing nowadays.
The committee on *Foundation of Manufacturing* has a noteworthy attempt to define the production philosophy, which says that, principles and theories must provide guidance in decision making and operations, they must be action oriented, and their application should leads to improvement of performance.

According to [1], Umble and Srikanth have pointed out few important elements for manufacturing philosophy, which are as follows:

- Definition of the common goal in terms that is understandable and meaningful to everyone in the organization.
- Development of the causal relationships between individual actions and the common global goal.
- Development of the causal relationships between individual actions and the common global goal.
- Guidelines for managing the various actions so as to achieve the greatest benefit.

Many people in manufacturing think that their recitations and prototypes of production process is channelizing their decisions and actions. But in realism such individual epitomes have been germinated from beliefs or rules of thumb that educed from personal knowledge or experience. They are usually inconceivable to enforce in new circumstances [1].

### 6.3.2. Traditional Production Philosophy

#### 6.3.2.1. The Conversion model

Many researchers have explored that traditional view of production is really loomed by *conversion model*. The conversion model in production can be delimitated as follows:

1. Process of production is a conversion of an input to an output.

   Many fields of study for example, economics and industrial engineering have used this inspiration as a foundation for apprehension of production. The model instanced below, admits for well-situated measurements of productivity in a given period of time.

   2. The conversion process can be fractioned into sub processes, and will be still conversion process.

   3. By reducing the cost of each sub process, the cost of total process can be cut down.

   4. Cost of inputs of process determines the value of the output from the process.
Statement 2 and 3 are particularly associated to the theories of control in a hierarchical organization. Whilst, statement 4 indicates that value is not vital in conventional philosophy. The cost of output can be raised via melioration of material and more experienced professionals [1].

6.3.3. Theories of production

6.3.3.1. Production as Transformation

All the activities which add value to the process is called transformation. The theory of transformation has been dominant during this century. The pattern followed today in production is basically based on it, and is basic principle in operation management. The origin of transformation has been noticed in economics and it is also called as Walrasian production model (this idea has been proposed by Walrasian in 1952).

The framework of the model is fundamentally made up of the technical coefficients, and provides us the ratio between the amount of certain production and the amount produced of a given product. However, there are limitations of this model and for overwhelming of these limitations; three generalizations are brought into overwhelm them.

The first generalization of Walrasian production model concerns a graph called Product graph (P-graph). This graph helps us to represent the arranging of product into assemblies, subassemblies and components (bills of materials).

The second generalization leads to organizational structuring of resources. These are distinguished by so-called R-graphs, which describes how resources are fused together
and arranged into different groups, departments and factories. This generalization embraces both social structure and physical layout respectively.

Finally, the third generalization leads to dynamic control model, management of resources, management of products and synchronization. These actions are studied on special time horizons.

Certainly, the relation between P-graph and R-graph can be considered as management of production. The aim of management is to bring out and supervise work orders for engineering and production.

The transformation model has been theoretical institution of scientific management, mass production and the modern corporation. These disciplines arose at the beginning of 20th century, including modern production control and project management.

According to [16], scope management is the raison d’être of the project management. The scope is determined through the work breakdown structure. The principle of scope management is that, sufficient work is done, superfluous work is not done and the work done is value adding.

Hence, it is very clear that the knowledge areas of project management are solely founded on the transformation notion and “its principle of hierarchical breakdown [16].

6.3.3.2 Production as Flow

Flow activities are non value adding activates during the production processes e.g. transportation, waiting, inspection, etc. this scientific concept was first proposed by Gilbreths (1922), which provided foundation for JIT (just-in-time) and lean production. This idea was firstly interpreted in 1913 by Ford, but the people didn’t paid attention to the templates provided by them. Finally from 1940 in Japan, the concept of flow production was further formulated first as part of war production and later at Toyota. In the following, vital behavior and managing of flows are illustrated.

Waste

Gilbreths suggested that the flow model is composed of four stages i.e. processing, inspection, waiting and moving. Similarly the effective way to improve the transformation is to eradicate non-transformation activities.

Cycle Time Reduction

The vital accomplishment by the lean production is to reduce the cycle time by eliminating non-value adding time. The cycle time can be interpreted as follows:

\[
\text{Cycle time} = \text{Processing time} + \text{inspection time} + \text{wait time} + \text{move time}
\]
The compaction of cycle time forces the diminution of inspection, move and wait time. Generally the main concept was to eliminate waste from the flow processes.

**Little’s Law**

According to Little’s law, the following formula for the relation of cycle time and work in progress in any production line can be derived:

\[
\text{Cycle time} = \frac{\text{Work in progress}}{\text{Throughput}}
\]

**Pull and Push**

Normally push system plans the release of work but pull system on the other hand, plans the release of work on the ground of system status. The fundamental feature of the pull system, for instance kanban, set up a cap for work-in-progress, and it is also stated in Little’s law, to keep the cycle time in control.

A production control system can be a mixture of both push system and pull system at the same time. Huang and Kusiak demonstrates a push-pull system that pushes through certain stages of manufacturing and pulls at other stage of production, depending on features of these stages of manufacturing. They argue that this push-pull system is better that only push system or only pull system.

### 6.3.4. The traditional conceptualization of construction

The construction industry is deliberated to be an old industry among others in this modern world. Particularly after Second World War, different proposals have been purported to understand construction and its problems, and to acquire jibing solutions and enhanced methods. We can acknowledge strategic initiatives like industrialization, total quality management and computer integrated construction. Some operational and tactical techniques also have been introduced, such as project planning and control tools, organizational methods, project success factors, and productivity improvement methods.

The general concepts of the construction seems to be a set of activities targeted at a certain output i.e. conversion. This vision of the construction is partaken by both old conventional methods of the construction and the new methods as well.

Cost estimation in traditional method is calculated by merely dividing the whole task into its constituent, and cost of postulated materials and labors are estimated for each element. This is what happens in conversion model, it is understood that total production process is composed of sub process which convert input to an output. [1]
6.3.5. Factors affecting productivity in construction

Site productivity in the construction is assumed to be a multifaceted system of interrelated variables e.g. psychological, structural, technical, environmental and managerial. Whilst, the prevalent effect on labor productivity is managerial practices, which are as follows [13],

1. Planning
2. Communication
3. Work environment
4. Fair but firm discipline
5. Ability to recognize and reward exemplary efforts

The other factors which are affecting the productivity on site are as follows

- Supervision
- Labor skill
- Manpower availability
- Job satisfaction
- Worker motivation
- Employee attitude
- Safety
- Union work rules
- Management capabilities
- Contractors scheduling
- Communication
- Project drawings and specifications
- Time required for decision
- Owners scheduling
- Degree of difficulty
- Technology level
- Material availability
- Equipment suitability

It is a very difficult task to ascertain the factors which effect site performance. Because these factors may vary from site to site, nature of production, companies, area, etc. That’s why it is difficult to determine one set of factors which are essential for production on site. Many researchers have worked a lot on it and finally divided the factors into different groups. These factors are categorized in activity, site, firm, and sector. The important factors are divided into different categories, which are as follow [13]:
1. **Activity**

- Weather
- Delayed materials
- Skill of workers
- Motivation of workers
- Equipment suitability and reliability
- Group relationship
- Payment practices
- Repetition of work operations

2. **Site**

- Management ability in planning and supervision
- Mix of inputs such as subcontractors and prefabricated material
- Size of the project
- Design of the project
- The contract
- Site layout and complexity
- Personnel turnover
- Communication
- Late decision and changes by owners

3. **Firm**

- Technology level
- Firm size
- Information practices
- Motivation of the management
- Type of contractor
- Production mix
- Purchasing and logistics practices

4. **Sector**

- Employment rate
- Financial situation
- Regulations

**6.3.6. Conceptual basis of the new production philosophy**

The conceptual basis of new production philosophy is a combination of different ideas of different models proposed in various fields e.g. JIT movement and quality movement. The main theme of this new production philosophy is to develop a model encompassing all vital features of production, especially those that are missing in the conventional
production model (conversion model). The new production model can be classified as the flow of material or information from raw material to the final product (fig-11). Normally in flow process, the material is processed, inspected and waiting or moving. All on going processes corresponds to conversion aspects of production, and mean while inspecting, moving, and waiting corresponds to the flow aspects of production.

![Diagram of Production as Flow Process](image)

**Figure 11: Production as flow process: simplistic illustration.** The shaded boxes represent non value-adding activities, in contrast to value-adding processing activities [1].

Distinguish features of flow process are time, cost and value. Value adverts to the customer satisfaction. Normally in most cases, it is assumed that only processing actions are value-adding activities.

New production philosophy entails dual aspect of the production. It is consisting of conversion and flow as well. In conventional approach, all activities disburse cost, consume time and only conversion activities add values to the final product. Hence, the primary focus of flow process is to concentrate on reduction or elimination e.g. waste and cost, whereas conversion activities have to be more effective. The central idea of new production philosophy is illustrated in fig-12.

By following heuristics principles, flow process can be designed, controlled, and improved in practice. These processes are as follows [1]:

1. Reduce the share of non value-adding activities.
2. Increase output value through systematic consideration of customer requirements.
3. Reduce variability.
4. Reduce the cycle time.
5. Simplify by minimizing the number of steps, parts and linkages.
6. Increase output flexibility.
7. Increase process transparency.
8. Focus control on the complete process.
9. Build continuous improvement into the process.
10. Balance flow improvement with conversion improvement.
11. Benchmark

![Figure 12: Performance improvement in conventional, quality and new production philosophy approaches. Note that the customary quality view address only a subset of all non value-adding activities [1].](image)

Normally principles apply on both to the total flow process and to its sub processes. In addition its shows the problems of flow processes such as complexity, transparency etc. [1]

### 6.3.7. Flow problems induced by traditional managerial concepts

The unfavorable judgment about conventional managerial concepts can be organized in three groups, which are sequential method of project realization, lack of quality consideration and segmented control respectively. The substantiation effects of managerial concepts in manufacturing are more visible.Whilst, it is stated that many non-optimal flows and increase in non value-adding activities are just because of managerial principles, which often breach the flow process design and improvement.

In following, many blemish of traditional managerial concept have been explained, which are as follows:

<table>
<thead>
<tr>
<th>Performance improvement rationale:</th>
<th>Conventional view</th>
<th>Quality view</th>
<th>New production philosophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost of a process</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                               | Increase           | Reduce cost | Reduce or eliminate      |
|                               | process            | of non quality and increase | non value-adding activities and increase |
|                                | efficiency         | process efficiency | efficiency of value-adding activities |

|                               |                   | Cost of non- | Cost of non-value-adding |
|                               |                   | quality      | activities               |
|                               |                   |              |                          |
|                               |                   |              |                          |
6.3.7.1. Sequential method of design and engineering

In this method, total task is carved up into temporally sequential task, which are later on handled to different professionals for execution. Similarly, the same concept is adopted in the conventional approach to the execution of the projects in the construction. In the traditional concepts of construction, client foremost picks out an architect, who develops whole designs and specifications for the project, and followed by designs for structural and mechanical disciplines.

In recent years, the crisis of conventional approach has been extensively discussed: which are as follows; [1]

- There are very little or no iterations in the process of design (long cycle times).
- Constraints of subsequent phase are not taken into account in the design phase (poor consideration of requirements of next internal customers)
- Unnecessary constraints for subsequent phase are set in the design phase (poor consideration of requirements of next internal customers)
- Little feedback for specialists (poor process transparency, segmented project control)
- Lack of leadership and responsibility for the total project (segmented project control).

Similarly, the successive operation guides to following [1],

- Suboptimal solutions
- Poor constructability and operability
- Large number of change orders
- Lack of innovation and improvement.

6.3.7.2. Traditional approaches to quality

In traditional managerial approaches, there is no exceptional exertion made to abolish deficiency, errors, omission, etc. and to condense their affect. It has been also thought that conventional approaches have fixed optimal level of quality. The processes with quality problems are unreasonable variance, poor detection of deviation, and unsatisfactory consideration of customer satisfaction.

6.3.7.3. Segmented control

In conventional approach, not the whole process is controlled but only few flow processes took under consideration and the reason for that is hierarchical organization. In hierarchical organization, control centers on organizational unit or task. And that’s why it leashes to maximization of consumption rate and to hefty consignments.
A typical example of the construction can be found in management of materials. Responsibilities for different assignments are divided between numerous individuals, regarding the material flow. The special departments often handled the purchasing of materials, which only concentrate at minimizing the total purchase and transportation cost for each material. This is one the reason for not having best possible flow of materials on construction site.

There are the following disadvantages caused by this [1], which are as follows;

- Space and attention required for materials and work-in-progress (WIP), deterioration of WIP through natural elements, loss due to misplacement, theft etc.
- Error correction is too slow
- Multiple handling

Enhancement can be achieved, but will really require co-operation from numerous units, which is very difficult at these circumstances [1].

### 6.3.7.4. Network planning

The network planning involves number of division of flow process into further sub activities, which are then coordinated into some good succession to achieve the shortest duration. When an action is a component of a spacious work flow, it is strongly impacted by the preceding activity. If the nature of the activities is same, knowledge and many advantages can be achieved and the set-up time can get reduced. The expenditure of the management and control moreover depends on the stability of the work flow.

The starting time is just determined by the network method, and doesn’t contrive the flow itself, even if an activity is a complete work flow. At the same time, traditional network planning conk out to hold up the planning of work flows of the project squads or material flows and may possibly guide to suboptimal flows. [1]

### 6.3.7.5. Neglect of flow control and improvement

In the traditional management of construction, many researchers have analyzed mismanagement. For instance, if we look at project planning, owners simply just start lump sum projects with bundle of uncertainties. The harmful affect of alterations is not exactly grasped. The true affect of changes isn’t well interpreted in terms of cost and schedule adjustments but it have been noticed that 40-50 percent of working hours are undervalued because of alteration in project planning.

Nowadays, it is not normal for contractors to have formal preplanning in construction. The construction planning must guarantee fluent information, material and work flows. At the same time many researchers have found that material management is generally neglected in the construction management. Many small or big sized contractors, until
now didn’t notice that they can get healthy, dependable and profitable business by improving the material management of their company. [1]

6.3.8. Waste in conventional construction

It has been seen that there has never been methodical effort to scrutinize all wastes in the construction process. However, many researchers have worked on it from different countries and can be used to point out the enormity of non value-adding activities in construction. There are many reasons which lead to non value-adding activities in construction process such as local conditions, project types, construction methods etc.

Quality costs are believed to be the best reached area. Many studies have proved that cost of poor quality has turned out to 10-20 % of total cost of the project. In an elaborated Swedish study on design-construct project, quality failures valued for construction company were of 6%. And similarly American study of numerous industrial projects, the deviation was recorded to be 12.4% of the total installed project cost.

According to Business Roundtable study, materials management was discovered to be mostly disregarded. It has been approximated that 10-12% of savings in labor and 10% of saving in material cost can be achieved through effective material management system. According to Swedish research, 10% consumption of extra material has been recorded, altering in range of 5-30% for different material in construction process.

Hence, it is proved that there is a significant quantity of waste and loss of value endured in construction industry. A magnanimous part of this waste has been blotted out and not enough actions have been considered [1].

6.3.9. Classification of construction waste

Usually waste in the construction comes from flow activities, conversion activities, and management activities. Their occurrence is normally demonstrated by two ordinary construction circumstances, which are work inertia and effete work. Information accumulated from many construction projects helps in categorizing wastes of construction, which is shown in fig-13.

The compartmentalization shown in above figure has some limitations, which have to be considered.

1) Decelerated work and wastage of time is associated with effectiveness of processes, recruits, and construction paraphernalia. Whilst, it is difficult to calculate optimum efficiency that could be accomplished, which is normally difficult.

2) Rework is not always because of labor ineffectiveness, but other reason e.g. weather conditions, earthquakes etc. also leads to reworking, but they can be precluded [17].
6.3.10. Classification of waste causes

The most important factors, which lead to wastage of time and increase the cost of projects, are shown below in fig-14.
According to [17],

**Controllable causes associated to flows**

The main causes for flow are as follows:

1. **Resources**
   - Materials: Deficiency of material at site, unsound allocation of material, poor transportation
   - Equipment: poor accessibility, incompetent utilization, insufficient equipment to accomplish the work
   - Labor: personal approach of workers, occlusion of work

2. **Information**
   - Lack of data
   - Poor quality of information
   - Timing of deliverance is poor

**Controllable causes associated to conversions**

The following causes were discovered:

1. **Method**
   - Insufficient design of working team
   - Poor procedures
   - Poor accompaniment to work activities

2. **Planning**
   - Deficiency of work space
   - Many people working in limited space
   - Poor working conditions

3. **Quality**
   - Poor execution of work
   - Damage to finished work

**Controllable management related causes**

The following reasons were identified:
1. **Decision making**

- Poor distribution of work to labor
- Poor distribution of recruits

2. **Supervision**

- Lack of supervision

There are some other reasons, which play an important role in wastes during construction, which are connected to environment e.g. weather conditions and festivities etc.

### 6.3.11. Conclusion

From the above research it is very obvious that conventional theory of production in construction is outdated. The conventional theory of production was basically riveted on conversion model e.g. the concept of mass production was basically focused on conversion model. Flow model wasn’t regarded before, and for the first time got introduced in manufacturing from Toyota car industry in Japan.

The main centralized area of lean technique is flow model and JIT (just-in-time). Lean, for the first time considered the non-value adding activities in a process and reduced the waste caused by these flow activities. Lean technique is more explained in coming chapter.

### 6.4. Lean Production

#### 6.4.1. Introduction

The chronic problems of the construction industry are very well known to every body. The problems can be classified as low productivity; poor safety, mediocre working conditions, and poor quality etc. Researchers have really worked hard to overcome these problems, and proposed many solutions to relieve these problems in construction industry. Industrialization (prefabrication) has been considered as one of the direction for development. Computer integrated construction, robotized and automated construction, was also believed to reduce the fragmentation in construction industry.

In last two decades, there has been a great enhancement in the manufacturing industry. Manufacturing industry has been an orientation course and a source of innovation in the construction industry for a long time e.g. the concept of industrialization comes straightaway from manufacturing. Nowadays, lean automobile industry is now using a reduced amount of every thing i.e. almost half of human exertion, product development
time, investment in tools etc. There has been a significant enhancement in manufacturing industry, which challenged the classic epitomes of conventional production. All these achievements and improvements have not been turned out because of drastic change of technology, but it is a result of the application of production philosophy, which guides to Lean Production. This new production philosophy is amalgamation of partial approaches as JIT, TQM (Total Quality Management), time-based competition and concurrent engineering. Until now, in construction industry, the concept of lean is new, but several companies have started to discover the application of the lean techniques to the construction industry.

The new production philosophy or lean techniques identify two types of activities in production system. Firstly, conversion activities are those which add value to the process and leads to the value of the final product. Secondly, flow activities which is considered to be non-value adding activities e.g. inspection, waiting, transportation etc. The main theme of the Lean Production is to minimize the flow activities and focus on improving the conversion activities, which leads to the value of the final product. In the conventional construction management (project management in construction), the consideration has been centralized on conversion activities, and the flow activities have not been enhanced or ascertained.

During last few years, the researchers have put their exertions to scrutinize the application of lean production to construction industry. Researchers have suggested new approaches to lean production in construction (lean construction) and worked to encourage the new production philosophy in construction [17]. In this regard, International Group for Lean Construction—IGLC was founded in 1993. The purpose of this group or organization was to meliorate the process and production in the construction industry through new production philosophy. Afterwards, in 1997, Dr. Glenn Ballard and Dr. Gregory A. Howell, both associates of IGLC, established The Lean Construction Institute—LCI in San Francisco. LCI is basically non-profit-making organization, and researching for tools and methods, that can help construction companies to become more profitable and competitive in market [18].

6.4.2. Origins and diffusion

The idea of the new production philosophy firstly sprang up in Japan in 1950. The most outstanding application was the Toyota production system. The fundamental inspiration of Toyota production system is liquidation of inventories and other small wastes of production, reduced set-up time, self-directed machines, co-operation with suppliers, and other proficiencies.

These ideas were extended and processed by industrial engineers, after a long process of trail and error. Until the commencement of 1980, the information and understanding of the new approach (lean production) was limited in the western world. Nevertheless, the ideas disseminated to Europe and America in the beginning 1975, specifically in the automobile industry.
In the beginning of the 1990’s, this new philosophy of production, which is known by many names (world class manufacturing, lean production, new production system, Toyota Production System) starts emerging in the market. It is partially practiced by many major manufacturing companies in America and Europe. Mean while, lean production has been experiencing further more maturation especially in Japan. New approaches and tools have been established to maturate the philosophy, for example Quality Function Deployment (QFD), Tuguchi-method, design for manufacture, etc.

In 1982, Japan leaded to an organization for the new approach that is New Production System (NPS) Research Association, for rectifying and implementing the new production system in associate companies [1].

### 6.4.3. Conceptual framework

The lean production is simply composed of two main activities and i.e. conversion and flow. Conversion activities are those activities which are adding value to the process and similarly flow activities are non-value adding activities. The main focal point of lean production is to manage and eliminate the non-value adding activities, similarly making adding value activities more efficient. The conventional production was dominated by conversion process and hardly concerned about flow activities in production.

![Figure 15: Different levels of new production philosophy [17].](image)

Due to the conventional managerial concepts, flow activities in production have not been managed properly. And as a result, extended to complex, diffident and fuddled flow processes, elaboration of non-value adding activities, and diminution of output value [17].
6.4.4. Basic principles of lean production

Lean production doesn’t embrace new principles of the management techniques. It simply mingles subsisting principles of today’s management. The major objective of lean production is to evade waste of time, equipment, money etc.

The main focus of the lean production is to reduce the cost and waste, during the execution. If truth be told, a lot of scheduling and decision problems can be debarred by generating lateral relations among working teams, and by avoiding them to get manage through hierarchical approach. The most important principles of the lean production are as follows:

6.4.4.1. Multifunctional task groups

Many authors and researchers believe that, multifunctional task group is one of most important instrument of the lean production. Rather than having homogenous working groups, multifunctional group can produce a variety of products. And similarly, this group can be held responsible for number of tasks, which can help in adding values to the production process. In multifunctional groups, there is no need for workers to wait for each others and it also avoids stocks. To achieve the goals through multifunctional task group, personnel has to be well trained and should know how to keep them combine, until the goals are achieved.

6.4.4.2. Simultaneous engineering

The world of technology is changing every day, and almost every day we have some new inventions or new technologies in the market, which also contributes in reduction of lifecycle of products. And this is one of the reasons for the reduction of product development. Simultaneous engineering can help to sustain the life cycle of the product development. In simultaneous engineering, there is no concept of detachment between designing and manufacturing of the product but are integrated simultaneously through mutual cooperation between designers and producers of product development team. The direct communication and collaboration can play important role in reducing the development period of products. Similarly, simultaneous engineering can help to reduce muda (waste) by keeping off miscommunication between production and engineering.

6.4.4.3. Kaizen

Kaizen is Japanese word, which means permanent and stepwise quality improvement. The main theme of kaizen is reducing the cost by using their astuteness capabilities. In reality Kaizen involves enduring new ideas for cost reduction. Some time it entails a stern demand from the management to every production units to generate new idea every week.
An authentic execution of Kaizen entails cost reduction and no shortcomings in the final products. It is very clear that kaizen guides to cutting down of muda (waste) in production process, but meanwhile asking for involvement of employees.

6.4.4.4. Just-in-time deliveries

The basic principle of Just-in-time (JIT) is good flow control. It energizes the reduction of stocks of material and controls the flow of good, when it is needed. Traditional production was fundamentally based on the mass production, due to which inventories got increased and finally leads to higher cost. Just-in-time (JIT) believes in small deliveries as compared to few and gigantic deliveries, which reduces inventories significantly.

The conventional stock control is grounded on elaborated scheduling techniques (push), while JIT is grounded on the fact of customer’s demand (pull).

6.4.4.5. Long term relationships with suppliers

The basic idea is to create collaboration with your suppliers, which means the following:

- Mutual technology transfer;
- Mutual ingenuousness;
- Mutual management support;
- Mutual declining of inventory;
- Mutual sharing-out of profits;

Long term relation is needed with suppliers rather then conflicts, which will finally lead to muda.

6.4.4.6. Customer orientation

The whole company should concentrate on the client, all the time. The relationship between client and supplier is playing an important role in successful business, internally and externally. Good communication with your client plays a significant role in reducing problems and muda at the same time.

6.4.4.7. Information, communication and process structure

Lean productions always call for transparent and limpid organization. A diaphanous and crystalline organization associates healthier information and communication, internal and external as well. Simple structure of organization facilitates the communication among the workers and higher authorities. A transparent organization helps to overview the effects of control actions and facilitates to assure the communication, because disturbance in communication can leads to increment of muda. [17]
6.4.5. Methodologies and tools

6.4.5.1. Overview

There are many factors which make difficult to demonstrate a rational overview of the ideas and techniques of the lean production. The field of lean production is quite juvenile in nature and in regular advancement. Lean production is based on two historically significant core terms, i.e. Just In Time (JIT) and Total Quality Control (TQC), which are explained below. These developments demonstrate that the field of application of the archetype has broadened far ahead from the production domain.

6.4.5.2. Just In Time (JIT)

The concept of new production philosophy is basically originated from developments pioneered at Toyota car factories in 1950’s (by Ohno and Shingo, according to [1]). The main idea was to reduce or obviation of inventories. This concept further more, leads to other techniques that were forced to grapple with fewer inventories, lot size diminution, layout reconfiguration, supplier co-operation, and set-up time reduction. Whilst, pull system in production demands for exact or actual resources rather than plans based on forecast.

The concept of waste is one of the most important keystones of JIT. On the basis of JIT following wastes were acknowledged i.e., inventories, waiting, over processing, overproduction, moving, making substandard parts and products. The main concern of JIT is to reduce the waste through continuous improvement of operation, equipment and process respectively.

6.4.5.3. Total Quality Control (TQC)

The assessment of raw materials and products practicing statistical methods was the initial point of the quality movement. In Japan, quality movement has been evolved from only bare inspection of products to total quality control. The term total adverts to three extension i.e. 1) amplifying quality control from production to every department, 2) increasing quality control from workers to management, 3) intensifying the concept of quality to wrap all process in the company.

The superiority of methodologies has evolved in association with development of the notion of quality. Before only inspection of process was enough to check the process, but now the spotlight has been changed from inspection oriented to continuous process improvement and currently to designing quality into the product process (Quality Function Deployment).

There has been constantly conflict between JIT camp and quality camp. The delegates from JIT camp always concentrate on process improvement and error checking at the source instead of statistical control and quality programs.
6.4.5.4. Total Productive Maintenance (TPM)

Total productive maintenance adverts to independent sustentation of production machinery with the help of small groupings of multi-skilled operators. TPM struggles to make the most of the production output by keeping the perfect operating circumstances. According to [1], without TPM, the Toyota production system could not function.

6.4.5.5. Employee involvement

There are many reasons for employee involvement in production process. Rapid response to any kind of problems demands for conferring legality of workers. Continuous development is intensely dependent on day to day observation, inspiration, and devotion of the work force. One of the ways to reduce the waste is related with division of labor, multi skilled teams, and experienced labor.

6.4.5.6. Continuous improvement

Continuous improvement directly leads to JIT and TQC. The main concept of continuous improvement is to sustain and improve the working standards through gradual improvements. The main target of the continuous improvement is to reduce and eliminate waste from the production process.

6.4.5.7. Benchmarking

Benchmarking is a technique which adverts to one’s current performance versus the world leaders in any exceptional area. In short, it means to adopt and implement the best practices in the world. Generally benchmarking is a goal-setting procedure, which is depended on business process rather than technologies used in them. The function of benchmarking was based on 1980’s work done at Xerox.

6.4.5.8. Time based competition

The concept of the time based competition leads to squeezing of time right through the organization for accomplishing the benefits, and this concept originally came from JIT philosophy. The benefits of squeezing time are reduction in work, reduction in inventories and make it easy to disclose the problems. There is no concept of JIT in administrative and information work but even though time based competition has become very popular.

6.4.5.9. Concurrent engineering

Concurrent engineering basically deals out with product design phase. Many researches and studies have remarked that concurrent engineering didn’t arise from JIT or TQC, even though both are sharing the common composition. While having comparison
between traditional design processes, iteration cycles are channelized to the preliminary stages through teamwork. The main objective of concurrent engineering is compression of the design time, reducing the number of change orders and to increase the number of iterations. Several tools have been formulated for concurrent engineering from the principles and system used in Design for Assembly and Design for Manufacturability.

### 6.4.5.10. Value based strategy

Value based strategy concerns with attaining competitive values in the market. The firms, which are using value based strategies, are customer oriented and absolutely not competitor-oriented firms. Continuous improvement is one of the essential characteristic of value based management.

### 6.4.5.11. Visual management

Visual management is more concern about visual control in the production, quality and workplace organization. The objective of the visual management is to make the standard useful and any variation or deflection should be acknowledged immediately. “This is one of the original JIT ideas, which has been systematically applied only recently in the West”.

### 6.4.5.12. Re-engineering

The concept of re-engineering is the fundamental reconfiguration of the tasks and processes, particularly with respect to implementation of information and technology.

### 6.4.6. Characteristics of Lean Production

Following are the main characteristics of lean production:

#### 6.4.6.1. Customer

The most important thing in lean production is the customer; it is the starting and end point of business in lean production. One of the specialties of lean production is value of the customer. Lean production always searches to maximize value to the customer. Lean production always take care of customers not on the internal operations, it really recognize the true demands of customer in price, delivery and quality.

#### 6.4.6.2. Simplicity

Lean production is not simple but believes in simplicity of processes of production. Simplicity means, simplicity in system, operation, control, technology, etc, which can be easily attained through averting of convolution. Simplicity can be achieved through
suppliers working intimately with few trusted associates. Special cautions should be taken against the complex computer systems, hefty automation, composite product lines, and complex incentive. The best way is to select the most easy, small, and reliable machine or production process with quality obligations.

6.4.6.3. Waste

Waste is epidemic to the business and to the organization, therefore it is important to recognize them and try to reduce them. Waste can be handled by excellent design of product and simple processes.

6.4.6.4. Process

Focus should be on the flow of the product, not on the movement of machine, people or services. Priority should be given to understand the process.

6.4.6.5. Visibility

Visibility formulates all processes and operations transparent and diaphanous. Visibility of processes always facilitates the progressing actions and recognizes the processes or time schedules, when they are distracting.

6.4.6.6. Regularity

In production, preference should be given to repeater products and should be executed in same time slots. This will facilitate to reduce inventory, ameliorates quality, and grant chasteness to control. The introduction of time pacing in new products can reduce the development cycle and can create good opportunities for innovation.

6.4.6.7. Flow

Flow seeks to keep the process momentum at the customer’s rate, and to keep the flow as one piece flow. Flow should be supervised at ground level in any company along with supply chains. If it is difficult to sustain the uniform flow, at least there should be pulse or small batches in flow.

6.4.6.8. Pull

The concept of pull is to produce at the rate of customer’s demand and to circumvent overproduction. The principle of lean is to have pull-based demand chain, instead of push-based supply chains. Pull should always be taken place on customer’s rate of demand.
6.4.6.9 Postponement

The impediment of activities, to produce as late as possible, and to retain suppleness, decrease waste and risk in the production. This notion is intimately consociated with the idea of debarring over production. This should be noted, that postponement doesn’t mean to produce a product at last possible moment, but is about maintaining flexibility at the exact level.

6.4.6.10. Prevention

Prevention avoids problems and waste, instead of fixing and inspecting. The best way to prevent the wastes is to inspect the process, instead of inspecting product.

6.4.6.11. Time

Time always leads to reduce the time to make, to deliver, and to introduce new products in the market. The best way to reduce the time is to implement simultaneous, parallel, and overlapping processes in operations. Always try to hunt for non value-adding steps, which can disturb the value-adding steps in the production. The mainstay of reducing time is to give to prioritize waste, flow, perfection and pull.

6.4.6.12. Improvement

The main concern of improving the production is continuous improvement. Continuous improvement helps in reduction of wastes and includes innovation in process of production.

6.4.6.13. Partnership

Partnership means working together both internally and among functions and externally with suppliers. Partnership depends on working teams, not on individuals. Employees can also be included in partners. In other words, it is about win-win situation not win-lose, it’s easy to find win-win situation rather then win-lose.

6.4.6.14. Value networks

The biggest chances for quality, delivery, cost and flexibility lie with co-operating networks. But this is the responsibility of every member to add value to the process. Lean production suggests elaborating the concept of one-dimensional supply chain to a two-dimensional value network.
6.4.6.15. Gemba

Taiichi Ohno, legendary Toyota engineer and father of TPS (Toyota Production System) said that “management begins at the work place”. The whole concept can be embraced by single word called Gemba. It tells us about, to find out where the action is taking place and to find out the facts. The main concept of Gemba is to have site inspection and walk around the site, where the work is in progress because execution of the task happens on floor, not in the office.

6.4.6.16. Variation reduction

Variation in the time and quality is very common in any kind of project. The best way is to cope with it and to reduce it. The management should look for different methods and tools to reduce the impact of variation in project because variation is the great enemy of the lean production.

6.4.6.17. Participation

Every one should have opportunity to share their views and to give suggestions to higher authorities. The operators should have the chance to resolve the problem, instead of concerning with higher authority. All employees should contribute to all successes and failures in the project. The main principle of participation is believe to be full information sharing.

6.4.6.18. Thinking small

The simple and easy production process or machine should be installed on production site. Importance should be given to the existing machines, instead of installation of new and complex machinery. Small plants should be installed near to customer sites. Lean production believes in delivering of many small batches, instead of delivering few gigantic batches.

6.4.6.19. Trust

The only tool which can help in participation and cutting wastes is to build trust among the coworkers. Trust is playing major role in saving time and money. Mean while, it gives the confidence to make investment and share knowledge.

6.4.6.20. Knowledge

Lean production believes in sharing and distributing of knowledge. The best example is Toyota car production. Now days there are many books, regarding lean production [19].
6.4.7. Aims of lean productivity

The essential elements of lean production are explained below. However, the advantages can exclusively be accomplished by the application of all following elements:

6.4.7.1. Processes transparency

The fundamental nature of this element is to make the process cycle more transparent. The detailed critical analysis can be easily obtained through lean productivity techniques. Every component of the process is examined and then classified as either a conversion or flow activity. This categorization of the process helps to improve overall production process by improving conversion processes, and by eliminating the flow processes. If it is difficult to eliminate flow processes completely, then it should be reduced to a possible extent.

Managers should always concentrate on the enhancement of conversion activities, which will leads to the increase in production. The process of conversion can be easily enhanced by improving the structure of organization, open communication, co-ordination, and regular flow of information etc. Responsibility should shift from supervisor to the workers; this will creates cultural conditions under which the workers will also contribute in decision making, rather than managers and higher authorities. By sharing responsibilities among workers, stability of flow and conversion improvements can be accomplished, instead of focusing on conversion activities only, which tends to be classical managerial approach.

6.4.7.2. Conversion improvements

The conversion activities are scrutinized by workers at regular interval, during the execution of processes. Which reduces the variability of output and consequently perks up the quality of a final product and reducing the conversion cycle time. Conversion improvements can be achieved by improvement in the quality of working life, experimental learning benefits and empowerment improvements.

6.4.7.3. Flow improvements

The flow processes are normally analyzed and improvements are accomplished by reducing the non-value adding activities in production process. The improvements and enhancement in production can be done in flow processes by modifying the whole process cycle by reducing the number of steps and relationships. Flow improvements leads to cost reductions for complete process and time reductions for the entire cycle.
6.4.7.4. Kaizen improvement conditions

Lean techniques generate quality and healthy situation for different additives and process design. The entire workforce should have the responsibility on their shoulders to amend the entire production system. The work force should work hard to bring these improvements in the organization rather than the management.

6.4.7.5. Added value improvements

It can be accomplished by systematic deliberation of customer requirements. It can be achieved by value chain analysis, which is composed of supply chain and client demand chain. The main theme of this analysis is to have the ability of close contact with regional markets as insider.

6.4.7.6. Output flexibility improvements

The enhancement in flow and conversion activities can step-up total productivity, and can also introduce the conversion activity at various stages in the process, which will improve the productivity and will be according to clients needs.

6.4.8. Techniques in Lean Manufacturing

The techniques of lean production fuse the competencies of the workforce with the organizational techniques to accomplish the better results with fewer resources. Lean production has been introduced by Toyota Production System (TPS), which was based on four major elements, which are explained below:

6.4.8.1. Just-in-time

JIT is basically grounded on the concept that inventories are not adding value to the process and should be considered as waste. Three methods are related with JIT. First, is kanban system (in Japanese, mean cards or sign), usually used to minimize inventories. Secondly, Production leveling guarantees that the demand variation can be best served by generating minimum lots for each product. And thirdly, reduction of set-up activities, believes in single minute exchange of dies. It reduces the activities to be carried out during downtime, so that exchanges should not get obstructed.

6.4.8.2. Automation

Automation is the new technique to prevent the defects, as compared to the traditional corrective approach. The Functional management system is first one to recognize automation, which encourages the cost and quality management. Second method is autonomous control, which leads to avoiding the flow of malfunctioning parts throughout the process.
6.4.8.3. Flexible workforce

It is always important to have flexible workforce, which can be attained by fulfilling the demands of workers. There are two methods which support flexible labor and i.e. multi-functional layout and standard operations. It is doable to shuffle emplacement in the production line and regulate the size of the working crew to the required tempo.

6.4.8.4. Creative thinking

Firstly, the creative thinking hunts for continuous improvement through response from workers on how to perk up their assignments. Secondly, the workers should look for the reasons of the failure and to prevent its reoccurrence. Thirdly, team work is required to get control on their activities and consent to task rotation. The human is the most important factor which makes lean manufacturing dynamic system, which can help in attaining higher values and performances. [20]

6.4.9. Comparison between conventional production and lean production

The conventional production philosophy is really dominated by the industrial mass production, which developed in the beginning of the 20th century. The most important differences between traditional and the new production philosophy is summed up in Table-2 below according to [17].

<table>
<thead>
<tr>
<th>Conceptualization of production</th>
<th>Conventional production philosophy</th>
<th>New production philosophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus of control</td>
<td>Cost of activities</td>
<td>Cost, time and value of flows</td>
</tr>
<tr>
<td>Focus of improvement</td>
<td>Increase of efficiency by implementing new technologies</td>
<td>Elimination or suppression of non-value adding activities, increase of efficiency of value adding activities through continuous improvement and new technology</td>
</tr>
</tbody>
</table>

Table 2: The comparison between conventional production philosophy and new production philosophy [17].
Similarly, the consequence of implementation of traditional and lean production philosophy are demonstrated in fig-16 in following.

Conventional production has been improved by the effectuation of lean philosophy or lean production. It has really affected conversion process and some how also contributed in flow processes as well e.g. computerized control systems, transfer lines and automated storages etc. However, the factors which were facilitating non-value adding activities were not controlled with the time, which finally headed to complexity and disturbance to the project.

![Figure 16: Conventional and lean production: focus of development efforts [17].](image)

The major discrepancy between traditional production and lean production is flow process. The flow processes are unequivocally embraced by the lean production, due to which it is possible to initially trim down the costs of flow activities significantly. The conversion processes or value adding activities are firstly developed through internal continuous enhancement and tweaking of existing machine. The implementation of new technologies in lean production is easier than the conventional production philosophy because less investment is needed to introduce new technologies and the production is better controlled. It means that after initial phase, it will be easy to increase the efficiency of value adding activities in lean production as compared to the traditional production. [17]

### 6.4.10. Lean Construction

Lean construction recognizes the Ohno’s production system design criteria as a model, but here the question arises that how to implement the Toyota system, lean production in the industry of construction? The construction industry has refused many inspirations from manufacturing industry because of the credence that construction industry is exceptionally different from manufacturing industry. In manufacturing industry, manufacturers formulate parts, and later on leads to project. But because of unique nature, uncertain environment and under great time and schedule stress makes it fundamentally special, as compared to making tin cans.
The lean construction management is healthier than the traditional construction management practices because it (According to [21]):

- has a clear set of objectives for the delivery process,
- is aimed at maximizing performance for the customer at the project level,
- designs concurrently product and process, and
- applies production control throughout the life of the project.

The current structure of the production management in the construction is stimulated by approach instituted in the mass production and the project management. The traditional construction management considers project as activity by activity, and meanwhile presumes that customer values have been achieved in designing. Normally the projects are managed by first breaking the project into pieces e.g. construction and design, then locating them in a reasonable progressions. Each activity is then subdivided into many more activities until each activity is handed over task leader, foreman etc. It have been noticed that current shapes of production and project management concentrates on value-adding activities and overlook flow and value deliberations.

Partnering makes a good sense when it comes to the perspective of activities. But many believes that partnering is used when failure in central control encounters and especially when project is facing high uncertainties and complexities. In these conditions, there must be a good communication among the representatives of each activity, without relying on central authority to be in command of message flow. Partnering is indication of disappointment in production management but it renders the chance for mutual redesign of the planning system to sustain close coordination and trustworthy workflow.

Lean believes in the development of team work and show compliance to transfer saddles along supply chains. The fusion of partnering and lean production made swift implementation possible. Where Partnering is more about building trust, where lean focus on reliability.

Many workers feel helpless victims of fate, when confronted with managing uncertainness in projects. They feel that, occurrence of uncertainties is beyond their control, but in lean construction and manufacturing, planning and control are the two sides of the coin that keeps on revolving though out the project. According to [21]:

- **Planning**: defining criteria for success and producing strategies for achieving objectives.
- **Control**: causing events to conform to plan and triggering learning and re-planning.

### 6.4.11. Techniques in Lean Construction

The most important determinants of construction are supposed to be workflow reliability and labor flow, but lean construction has changed the traditional view of the project as
transformation and embraces the concept of flow and value generation. Similarly, it shares the same objectives of lean production e.g. cycle time reduction, elimination of waste, and variability reduction. Continuous improvement, pull production control and continuous flow have been the direction for the implementation of lean construction.

Lean construction is composed of following techniques:

**6.4.11.1. Concurrent Engineering**

Concurrent engineering can be described as parallel execution of various tasks in multidisciplinary teams with the goal of obtaining most favorable products concerning functionality, quality, and productivity.

Many enhancements can be accomplished by using concurrent engineering. Scheduling could be recovered by network analysis (CPM and PERT). Many other opportunities can be achieved through overlapping activities, splitting activities and reducing the transfer time between different activities. The important planning parameters for scheduling concurrent activities are lead time, quantity, and risk under ambiguity.

Concurrent engineering is grounded on the team efforts, communication and information sharing are the keys for discovering new ideas. Whilst, partnering with subcontractors and suppliers can also bring good changes regarding concurrent engineering but the success of lean production is depended on the involvement of all participants in the early stages of the design.

**6.4.11.2. Last planner**

The last planner is the person or group of people which is responsible for production unit control, which means completion of individual tasks at the operational level. Last planner necessitates work flow control, which ascertains the stream of supply, design, and installation throughout production units. This can only be done by using look-ahead schedule, which determines the progression and rate of work. It carves up the master schedule into many packages, which specify the techniques of check capacity, execution, and establish a stockpile of standing by work. The scope of look-ahead schedule ranges from 3 to 12 week, which should be put in order by team work.

**6.4.11.3. Daily huddle meetings**

Daily huddle meetings provides a platform for the team members to share their views and to share what has been achieved, at the same time, talk about the problems they are facing during the production process.

**6.4.11.4. The Kanban System**

The strategy of Kanban is grounded on key components i.e. market place, supplier kanbans, collection vehicle, satellite stores, and inventory management system. Market
places are site warehouse that allocate different materials and small tools to the workers. Similarly, satellite stores are situated on site, where they get products from market places. Collection vehicle collect materials from preferred suppliers to the operational site.

Kanban use plastic bins as a signal to pull materials from suppliers to site, using the concept of just-in-time. Request forms are normally used as kanban signals between market place and satellite stores. The system of kanban starts normally with open doors so that the site can pull materials from the supplier up to certain perimeters. Subsequently, the material requested from suppliers arrives at market and products are later on picked from the stores, which are usually managed by recorder points.

6.4.11.5. Plan Conditions and Work Environment in the Construction Industry (PCMAT)

The purpose is to introduce a plan of health and safety into the project execution, called as Plan of Condition and Work Environment. These safety activities can generate limitations for scheduled tasks and that’s why it should be embraced as a part of assignments. All safety practices are therefore amalgamated in short-term planning, which can be analyzed through daily feedback from crew and subcontractors respectively.

6.4.11.6. Quality Management Tools

The fusion of quality management tools in the lean construction is based on the change from conformance based quality to the quality at the source. A point system is normally employed to evaluate the execution of planned controls, which will help workers to follow planned controls instead of quality corrections.

6.4.11.7. Visual Inspection

Visual inspection shows the uneven nature of the construction and leads to the application of visual tools for material, work and information flow etc. Identification of materials can accelerate repetitive processes and diminishes the risk of selecting wrong product. Progress charts and schedules can implement the dedication to the completion of tasks. Information and technology can also improve the communication between decision maker and executer, and can accelerate the process too [20].

6.4.12. Implementation of the new philosophy

It has been recorded that emotional and conceptual barriers are the most common factors, which create hindrance in the way for implementation of new philosophy i.e. lean production. Whilst, many managers think that, by the implementation of new philosophy their real lack of knowledge would be exhibited.
Experience illustrates that there are four important factors which have to be balanced, during the implementation of new philosophy. These factors are explained below:

6.4.12.1. Management commitment

A strong leadership is required to make the essential shift of philosophy for the improving of each and every activity in the organization. Change will be very unmanageable without a dynamic initiative from the management and meanwhile it is very important for the management to understand the aims of lean production.

6.4.12.2. Focus on measurable and actionable improvement

The concept of focusing only on developing capabilities should move to focusing on actionable and measurable improvement respectively. The focus should be on various processes flow and special attention should be given to their bottlenecks to accelerate the flow of information and material. The concept of short wins should be introduced for further improvements.

6.4.12.3. Involvement

Involvement of employee will transpire unsurprisingly, when hierarchies of organization are demolished, and meanwhile new organization is structured with autonomous teams. Control and development of the process will be under the responsibility of new structured team. And if still the hierarchy of organization remains unbroken, contribution can be motivated through problem solving teams. Therefore, we can say that the involvement of employee is very necessary but still not convincing enough for enhancement of continuous improvement.

6.4.12.4. Learning

The implementation of new philosophy in any organization demands for good experience and significant amount of learning from previous experiences. The learning’s should always guide to the tools and techniques of process improvement. Similarly in later phase, the spotlights twirl to empirical learning from operating processes and finally the source of learning lies in external information. [1]

6.4.13. Overcoming flow problems caused by traditional managerial concepts

The conventional managerial concepts have not only overlooked but also devolved the flows of construction. This was the reason to introduce unconventional methods to improve the flow of construction. Lean construction is trying to implement those flow design and enhancement principles which are breached by the notion of managerial method in conventional construction management.
These improvement actions to construction industry are as follows:

6.4.13.1. Alternatives to sequential mode of project realization

The problems induced in manufacturing by the sequential method of product development have been covered by the concept of concurrent engineering. The term concurrent has been introduced to improve the design process, and to minimize the changes in process until the design process. In assessment to the conventional sequential design process, iteration cycles are relocated to the earlier stages though cross-functional teamwork. Whilst, overlapping of phases have been used but passionate exchange of information is required.

6.4.13.2. Improving quality

Lean construction responded to quality issue by following three recommendations, which are as follows: (according to [1])

- Design and improve processes to have low variability
- Establish means for rapid detection and correction of any defect or deviation
- Improve the mechanism by which specifications are defined for each conversion activity.

These recommendations tally with flow design and improvement principles with reference to customer requirement, variability, and cycle time. Many construction companies are using these recommendations for resolving issues related with quality.

6.4.13.3. Non-segmented control

The fundamental solution is to concentrate on the complete flow process. It means that flows are the foundation for organization, instead of specialties as in hierarchical organization. For example, a manufacturer of a component or product is responsible for entire material chain, together with installation on site. “This will facilitate the application of other solutions developed in the JIT-approach to material flows, like smaller batch size and continuous flow, which contribute to cycle time reduction”.

6.4.13.4. From network planning to flow planning

The vehemence of working planning and materials management should modify to complete flow processes instead of discrete activities. Currently a lot of efforts have been made to fuse integrated flow planning with network methods to achieve best flow process in production. Lean construction will also endow with more profitable prospects for research and development, particularly computerized gizmos to execute flow planning effectively [1].


At present, the construction industry has produced products which have characteristics of manufacturing. These manufactured products consists of doors, elevators, prefabricated houses, windows and prefabricated concrete components (for example, pre-cast girder, diaphragm, pre-cast slab, etc) etc.

There are many examples of triumphant implementation of the lean production in construction, for example Schonberger reports on a Japanese factory which produces prefabricated house in forty days (from order to completion on site). Similarly a Finnish window manufacturer supplies delivery and installation of windows on the site with in fifteen minutes of accuracy. An American door manufacturer earned respectable profit through JIT production and short time cycle.

Many countries have made development concerning quality management. Many supplying companies have learned quality certification according to ISO standard. The applications of lean production have made construction industry very flexible, techniques and methods evolved in manufacturing can be easily practiced in construction industry. But very few factories or plants delivering to construction site have implemented the techniques of lean production except for quality management techniques. This means that, this change in construction industry will take time and will proceed after having some achievements.

6.4.14.2. Mainstream construction

The issues regarding quality have experienced increasing attention since in the beginning of 1980’s, and many general quality methodologies have been published. The problem of mainstream construction is that quality management mostly deals with fractional set of wastes, failures and customer requirements. Some how the implementation of quality management is more concerned to marketing and image, for instance ISO certification or acquiring national quality award, rather than focusing on internal problems.

The other process development principles are being exercised incidentally. A French construction company has arranged campaign for reformation of administrative procedures. A British construction company has adopted a strategy to be on-time, which means to reduce time variability in their processes. Similarly, Swedish company worked on reduction of cycle time for construction projects.

However, the common problem among all was that only few process design and improvement principles are being used. Therefore, quality management is being a handy and established entry point to the process improvement. There is a need to bang on to the application of all accessible principles of process design and improvement.
6.4.14.3. Industry wide initiatives

The conventional way of organizing the construction project has really strangled the performance improvement and innovation in many countries. Many European countries have tried to overcome through these problems by bringing changes in the organization to eliminate these obstacles. The changes are as follows; (according to [1])

- The sequential procedure in France
- The open building method in the Netherlands
- The new construction mode in Finland.

These methods have been adopted to overcome through the obstacles and to boost innovation in the construction. These methods haven’t been founded directly on new production philosophy. In approaches from different countries are described below.

**The Sequential Procedure**

The most important inspiration of the sequential procedure is to map the site work as consecutive understandings of autonomous sequences. A sequence can be defined as reorganizing of tasks by function of building rather than traditional techniques. After having sequence a firm can manage without intrusion because it is the only organization on working site. There is quality inspection and overturn of the progressing works after each sequences. In general sequential procedure focuses more on controlling of dates of different activities.

The sequential procedure tags along intimately with ideas of the new production philosophy. In the following an explanation of the processes and principles of the sequential procedure is prepared from the approach of applicable process improvement principles:

- Waste reduction: The objective is to lessen non-value-added time due to unnecessary specialization.
- Variability reduction: Preplanning is assisted through abbreviated external uncertainties.
- Cycle time compression: Sequence cycle time is squashed by developing more prefabrication.
- Simplification: Launching rigorously sequential work packages will help in reducing mutualities, which will help in simplification of organizing and planning of construction.
- Flexibility: It helped in improvement of multi-skilled personnel.
- Transparency: Visible material and information flows.
- Continuous improvement: Enduring interactions are formed among firms for a particular sequence, which alleviates continuous improvement and innovation.

The sequential procedure has been endeavored in many projects and the method has been further polished.
The open building system

The open building system is composed of, set of rules and agreements regarding the organization of design and building. The features of open building system are described below (according to [1]):

- Performance concept
- Modular coordination
- Separation of the “support” (structural) and “infill” (interior work) parts of buildings
- Specialized and multi-functional teams of craftsmen.

Particularly the following process design and improvement principles are accentuated:

- Elasticity of design solutions instead of getting dependent on pre-engineered and prefabricated elements.
- Simplification through modular harmonization and standardization of interfaces between various building components.
- Control of whole processes, while permitting authority of assessment for all concerned parties.
- Continuous improvement through project-independent product development by supplying companies.

This concept has been arisen over a period of 25 years and now being used by many contractors and suppliers in Netherlands.

The new construction mode

The objective of this new building process is to eradicate the causes of the problems in traditional construction industry. It usually conflates performance based design and final product oriented construction procurement. Many pre-engineered justifications have been introduced for different subassemblies of the building on the basis of supplier firms, performance requirements.

A detailed course of action has been prepared for implementing building projects by means of the new model. The principles of this model are described below (according to [1]):

- **Simplification**: Through chopping off dependencies among subprojects, the consequences of disturbances are reduced.
- **Control of complete processes**: Amalgamation of design and construction is promoted. Therefore, learning through feedback is improved and product development is facilitated.
- **Continuous improvement**: Continuous teamwork is to be building up with in firms and among the firms.
This model has been formulated in the end of 1980’s. During last two years in Finland, new building process has been the core issue of the debates. But this is understood that it can not be applied straight away, because it will result a lot of sudden changes. Nonetheless, it has been applied to a few projects on experimental basis. [1].

6.5. Last Planner System (LPS)

The Last Planner System (LPS) is a tool of lean production, which is grounded on the project planning and management system. Application of the LPS to projects has shown remarkable achievement in all four aspects i.e. schedule, safety, cost and quality respectively.

- Reduced project cost—workers usually expend less time while waiting for work or resolving problems regarding work in progress;
- Reduced project duration—the worker should not wait for available work;
- Improved quality—the work is done in its progression and brought out from one participant to other, when it fulfils standard criteria;
- Improved safety—the working environment gets more stable, flawless and protected.

The last planner system is the new operating system for the traditional project management, which helps in getting healthy values and minimizes wastes from production process. Usually planning takes place in a succession of conversations, each conversation verifies and develops project value. The traditional project management got failed to keep the workflow and to reduce the collective outcomes of dependence and uncertainty. This is the reason that each team use to have their own rate of productivity with little concern of expected work to be done till the next activity. Partnering and Design/build strived to resolve the problem by enforcing the organizational and contractual fixes but some how didn’t succeeded, because they were based on incomplete models of work [24].

The Last Planner System (LPS) was initiated to make the projects more certain, foreseeable and to finish the project on its deadline. It is also focused on building trust and nice working atmosphere among key project performers i.e. last planners (trade foreman on site, design team leader) and project managers. In LPS, the last planner is responsible to plan production week by week and make sure that work is ready before it is planned to be done. The project managers and last planners usually work side by side to make sure and understand the total process before they start working on project.
According to [25], there are four main elements to the Last Planner System:

- Programming Workshop—collaboratively creating and agreeing the production sequence (and compressing it if required)
- Make Ready—making tasks ready so that they can be done when we want to do them.
- Production Planning—collaboratively agreeing the production schedule for the next day or week
- Continual Improvement—learning about and improving the project, planning and production processes [25].

The Last Planners merely promise to finish the job in time when they feel that everything is clear and have enough resources to complete the task in time e.g. information, material labor, equipment and tools, transportation etc. Once job is done, the last planner notifies the site management or responsible team for the next task and to make sure that the task completed to proper standard.

### 6.5.1. Production Unit Control

Last Planner should always be cautious about the following critical quality characteristic of an assignment: (according to [26])

- The assignment is well defined.
- The right amount of work is selected.
- The right order of work is selected.
The work selected is sound i.e. can be done

The word well defined means that the scope of the work is cleared to all members of the team and can be finished at its deadline date. The right amount means that planners must analyze the work to be done in planned budget. Similarly, the right order means the order with project obligations, goals, and implementation strategies. And sound means that all requirements and resources are available for the execution of the task.

“Percent plan complete (PPC) is the number of planned activities completed divided by the total number of planned activities, expressed as a percentage” [26]. Percent planned completed (PPC) is a key measure of the certainty of work delivery for Last planner. During the execution of the project, each team leader guarantees to complete one or more activities by an agreed day of the coming week. In other words PPC is the evaluation made between promises made and product delivery time. PPC represents the current rate of progress to the project manager and also helps to uncover the hindrance towards the completion of the task.

Following figure (Pareto chart) uncovers the factors which play important role in reducing the PPC value in any kind of a projects [25].
6.5.2. Workflow Control

Workflow control means checking the movement of work between production units in a certain succession and rate. Production Unit Control brings together the execution of task within production units for example, construction teams and design teams. In the same way, Work Flow Control synchronizes supply, installation and flow of design all the way through production units.

The responsibility of lookahead process is to keep check on work flow in the hierarchy of plans and schedules. Lookahead schedule usually helps in spotlighting the task SHOULD be done in future. But lookahead schedule performs several functions in combination with Last Planner System, which is mentioned in following tables.

Generally, the number of weeks for lookahead process is determined on the basis of project characteristics, intervals for obtaining information, consistency of planning system, materials, labor, and equipments etc. Table-3 and Table-4 are the illustrations of construction and engineering lookahead schedules, which are as follows. Indeed it is always beneficial to have group of people those can plan the next phases of the project collectively and produce a phase schedule. It will give the opportunity to the workers of an organization to look beyond the window of lookahead, when it is needed.

Figure 19: Example of a reason Pareto chart [25].
Functions of the Lookahead Process

- Shape work flow sequence and rate
- Match work flow and capacity
- Decompose master schedule activities into work packages and operations
- Develop detailed methods for executing work
- Maintain a backlog of ready work
- Update and revise higher level schedules as needed.

Table 3: Functions of Lookahead Planning Process [26].

During the execution of the project, last planner subjects each task or assignment to constraint analysis, to conclude that which actions must be completed to make the assignment ready for an execution. The general rule is to look into the lookahead window and select the tasks that can be accomplished according to the schedule. In the meantime, if the planner is not convinced with all problems, so he can postpone the activities to the later dates.

6.5.3. Pulling and Last Planner system

Pulling is the process of introducing material or information into a production process according to the demand of the market. The alternative method is push, which introduces material and information according to the target delivery or completion dates. Construction industries have been using push mechanism, which was inspired by the Mass production.

The concept of pull is to allow materials and information into a process of the production, just when it is needed or capable of executing it. Lookahead process is dependent on pull mechanism, and is a function of pull techniques.
Table 4: Construction lookahead schedule [26].

Pull system is playing an important role in all kind of the productions, e.g. concrete have short shelf life, it cannot be ordered too far in advance. But auspiciously, the settling time of concrete is not too short, so there is usually a chance to wait and fix all the constraints (but not too long, keeping the time of settling of the concrete).

### 6.5.4. The Last Planner System as a whole

The last planner system introduces a factor of production control to the traditional paradigm of project management. Last Planner System can be interpreted as an instrument for converting “what SHOULD be done into CAN be done”. Therefore, forging an inventory for completed work and also will help in shaping Weekly Work Plans. This is the commitment by the Last Planners to fix assignments on Weekly Work Plans. [26]
7. Analysis

This document is basically focusing on the problems that construction industry is facing nowadays. This document shows that the construction industry has been using the philosophy of the traditional project management for a long time.

The present construction industry is facing a lot of problems, many projects are failing. The business of this industry is getting worse gradually, and many stakeholders are afraid to invest the money in construction industry.

The construction industry has been ruled by the concept called “mass production”, until now in some sectors. This theory was actually based on transformation, in which the production can be glimpsed as a number of separate steps and each separate step adding value to the final product.

In the last two decades, the manufacturing industry has brought great augmentation in their production. The manufacturing industry has been a source of innovation for the industry of construction for a long time, e.g. the concept of industrialization originated...
from manufacturing. Nowadays, lean automobile industry is currently using reduced amount of almost everything e.g. human effort, product development time, investment in tools etc. There has been significant enhancement in the industry of manufacturing, which has challenged the classic paradigms of the conventional production. All these achievements and advancements have not been booted out because of radical change in technology, but it is a result of the application of production philosophy, which leads to lean production.

During my study, I found that many construction project managers those who were using the traditional project management philosophy have been experiencing a lot of problems during the execution of their projects. The case studies included in this document (for more concern read appendices) provide evidences that, when project managers used the traditional way of managing the execution of project, they had low production values.

8. Conclusion

The industry of construction till today is following a traditional paradigm of the project management, which is basically following “theory of mass production”. Theory of mass production is just considering the value adding activities.

The industry of manufacturing is blossoming gradually, and has been playing important role in the innovation of construction industry. Japan has introduced a very simple and transparent technique in manufacturing of automobile industry, which has cut down the cost of production to half. This technique is called as “lean technique”.

Traditional paradigm of project management in the construction was only centering on conversion activities, which are adding value to the final product. Flow activities have always been ignored; flow activities are non-value adding activities during the production process e.g. inspection, waiting, transportation etc. And this is one of the reasons for a lot of rework in the projects. In big projects, these reworks can be very small but its overall affect costs a lot of money and wasting of time.

This document demonstrates that the present doctrine of the project management experiences severe lack in its theoretical base. It is grounded on poor definitions of planning, execution and control. These deficiencies in theory of project management has forked up education and training more difficult, and similarly has hindered modernization and maturation of project management.

During the implementation of lean techniques, it isn’t only necessary to motivate your workmanship for its implementation; trust is the most important key, which can advance all towards a common goal. Similarly, it’s important for project manager to have good communication skills, good planning for his business, should have good knowledge of problems and their solutions, stable decisions, policy making expertise, good performance management etc. If the project managers have these qualities, he can easily
implement tools of lean philosophy and can cut down the budget of the project in a very friendly atmosphere.

The project manager should focus on support of top management, inadequacy of implementation, supervisor confrontation, employee confrontation, training to new tools of lean, getting all team together for change etc, to improve the operation and execution of the project.

Case studies in this document (for more details concern appendices) demonstrated that when LPS was implemented, it gave us healthy values of PPC as compared to the absence of LPS. Through LPS we can achieve value more than 90%, if it is implemented sagely.
9. References


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10. Appendices

10.1. Case Studies

In this chapter, we are going to demonstrate the major results achieved with the implementation of lean techniques in the construction industry. Our focus is on “Last Planner System” among various tools of the lean technique. Whilst, it will demonstrate the examples of a site construction in which the concept of the lean techniques has been deployed for decreasing costs and terms, and amending the level of quality.

Following are the few case studies, which have employed the “Last Planner System” as an important tool to cut down the cost, wastes and to improve the quality of the last product.

10.1.1. The Production Management Center (GEPUC), Catholic University of Chile

The Production Management Center (GEPUC) from The Catholic University of Chile premeditated research work along with different companies. There main goal was to implement LPS (Last Planner System) during different phases of the project.

Figure-20 shows average PPC (Percent Planned Completed) during the year of 2001 to 2003. Many companies improved their average PPC with marginal percentage.

During the research work, they found that poor planning & field interference were playing an important role in the non completion of the projects. The other main problems were factor of subcontractor, poor planning, field interference, poor planning of materials.

Many companies improved their productivity with good margin, when they implemented the tools of lean production (LPS). But at the same time, many companies faced a lot of problems. GEPUC discovered common hindrance to the implementation of LPS, which were lack of time, lack of training, bad organizational structure and lack of self criticism [23].
10.1.2. Housing Project in Quito, Ecuador

This was the housing project in *Quito, Ecuador*, which was covering 102 one-family units, embracing 80,000 square foot. The planned budget was $860,000 USD, construction started out on April 23, 2001, having the time period of 193 calendar days.

The project management of the company decided to put Last Planner System (LPS) into the project, with mutual understanding between technical management team and contractor. The main issues for the project management team were the assignments, which were demanding more resources, budget for the project e.g. foundation, masonry, structure and finishes.

The contractor was very successful to implement the LPS in the beginning of the project. But as the work was progressing, contractor started loosing the threads of the tools of LPS in the later stages of the project.

The best value of PPC was attained during the last 2 weeks of foundation. The main reason behind this success was that, contractor used the same working crew from beginning to the end of foundation and structural stages.

During the execution of the project, project manager faced variation in the values of PPC (Percent Planned Completed) and PF (Performance Factor) respectively. The main reason for this variation in values was the improper use of lookahead schedule. According to the
GEPUC, main reason for non completion of tasks were constant change in priorities, lack of resources, crew’s size, lack of prerequisites.

The above case studies show us the importance of the lean tools during the execution of the project. Due to the improper implementation of the lean tools, project manager faced a lot of problems, and if the project manager could have concentrated on these issues, there could have been no variations in the values [27].