INGENIOUS USAGE OF LEAN MANAGEMENT ON CONSTRUCTION PROJECTS

S. Binil Sundar*

ABSTRACT

Performance is the key word in the construction industry. Dictionary defines performance as "the manner in which or the efficiency with which something reacts or fulfills its intended purpose". The way to do things in a right manner with right amount of capabilities means putting the best foot forward from one's side. And if the result is successful, ace up your sleeve.

Many construction industries are suffering in this competitive world because of lack of performance; which are due to many reasons, be it non-productivity, non-delivery, loss, bad organizational skills and many more. Similarly, neglecting the issues likes eliminating wastes and value-addition are not thought of even though these are highly important. No wonder Abley and Woudhuysen (2004) do mention about construction going backwards. Among this entire environment, Lean Production has made a name of its own in a big way.

The principle behind Lean Production was developed by car manufacturer Toyota led by Taiichi Ohno. Focus was totally on value generation and complete elimination of wastes throughout the production phase. This report is about analyzing a construction scenario (Firm X) and adoption of Lean Principle in that particular organization.

Performance is the key word in the construction industry. This report deals with evaluation of current working method with the problems generated in a construction organization. It also identifies and lists out the problem Firm X is facing on all level. Also it briefs the rehearsal of Lean, its goals and principles. This paper is about implementation of Lean Principles into the given organization. Here, the focus is on trying to solve each and every problem faced by Firm X and further improvement of the organization. Different Lean Principles are being taken from 14 principles of Lean, JIT, 5-S and The Last Planner. Also workable strategy of Agile Project Management is being discussed. Lean Implementation requires deep techniques and knowledge and is not an easy task. Therefore this report deals with applying Lean in Firm X. It lists out recommendations for applications, its explanation and adoption in Firm X.

* Asst Professor – Civil Engineering Department, B.S Abdur Rahman University, Chennai, India.

The Current Scenario- Firm X

1.1 Introduction: Firm X; the construction company was quite reputed in its field in India. Known to have good client relationship, Firm X wasn't spared with all constructions problem either. Even though it handled its projects really well most of the time, it would not be wrong to state that each alternate project suffered from typical construction problems.

1. 2 Current Method of Working: Most of the projects in Firm X were handled according to RIBA plan of work since it is widely accepted as in operational model throughout building industry. (See also Appendix 1 & 2: For Process Protocol Maps used for Firm X)

RIBA Plan of work is basically categorized into these fol owing phases:

a. Feasibility
b. Design
c. Pre Construction
d. Construction
e. Post Construction

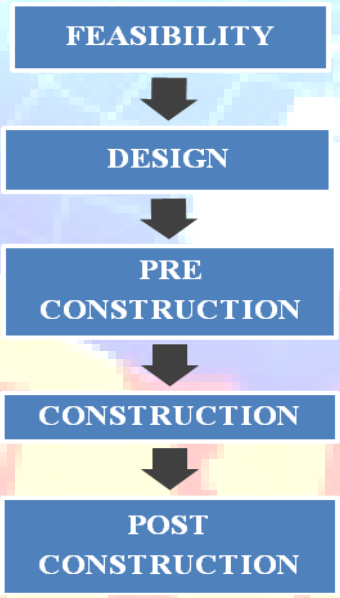
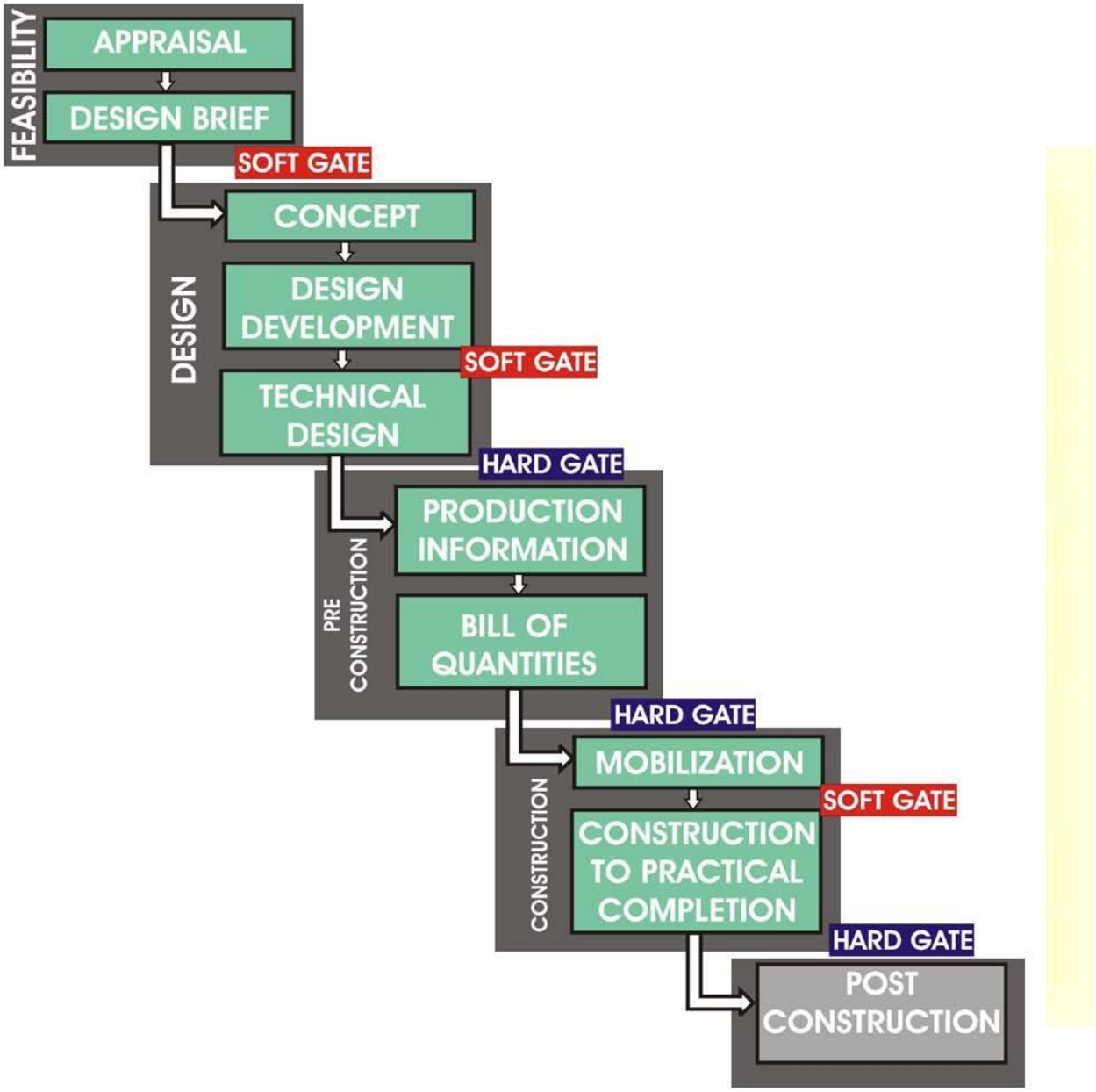


Figure 1: Key Phases

Firm X generally dealt from generally upon last three stages: Pre Construction, Construction and Post Construction after getting Design and Client's need; Firm X did have equal contribution and involvement in first two phases.

Within these key phases, there would be stages also known as sub processes. Any project needs a vision and key performance indicators to be identified up front. They should be assessed at each stage to monitor achievement and check that they are still appropriate, hence were necessary soft and hard gates in between the phases.

Figure 2: RIBA Plan of Work Flow



The detailed description for the phases and stages are as follows:

a. Feasibility: The first phase would be realization of need for the project and client's main objective in this project. This phase would consist of two stages-

i. Appraisal: Identification of client's needs and objectives and then the preparation of feasibility studies and assessing it. From that to derive what resources will client can make available and what needs to be sorted out.

ii. Design Brief: Important role of the client as it would be looking at key requirements and constraints. Then getting the vision of project on the paper and developing of design brief. Initial procurement option would also be decided where in Firm X has active involvement.

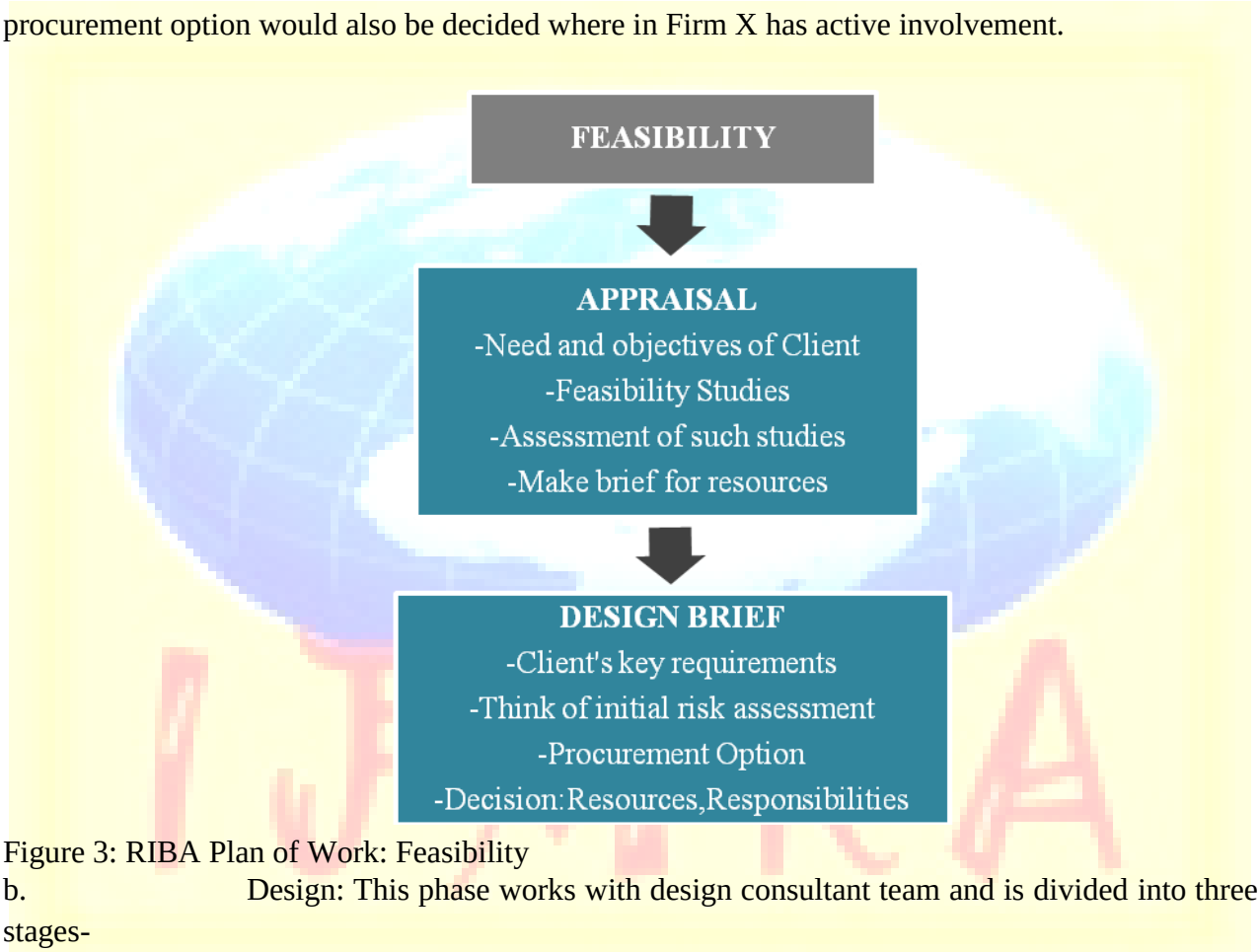


Figure 3: RIBA Plan of Work: Feasibility

b. Design: This phase works with design consultant team and is divided into three stages-

i. Concept: Implementation of design brief and putting up of additional data. Preparing the concept design with thoughts on building service systems and specifications.

ii. Design Development: Developing concept design into full fledged design with all services and facilities and cost plan. All approvals will be obtained at this stage, including for Building Regulations.

iii. Technical Design: Preparing technical and structural design and specification according to standards and regulations. The procurement method adopted is finalized and any kind of big further changes would be minimum for smooth flow of the work. Since technical design was necessary for Firm X to understand the project, the organization had active

input and involvement in this sub process.

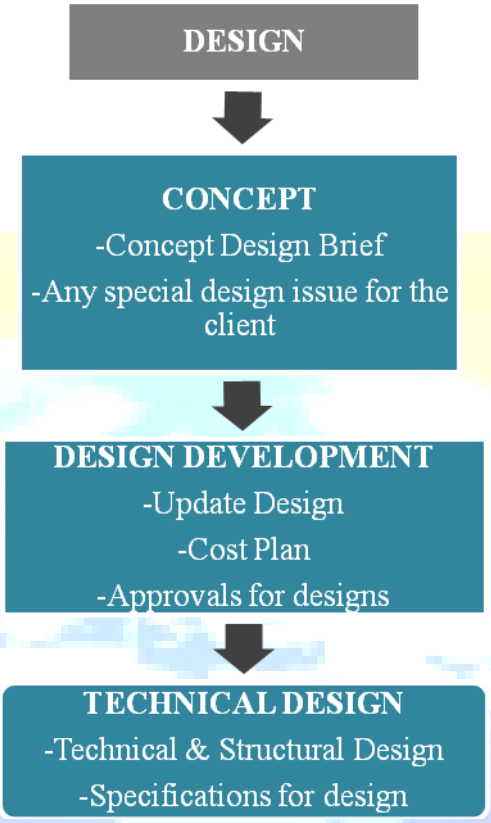


Figure 4: RIBA Plan of Work: Design

From here on Firm X takes over most of the part of the Project.

c. Pre Construction: Just before starting construction, this phase comes under which the stages are-

i. Production Information: Preparation for detailed information for construction related to all fields of project on matter of design, specification, construction and cost. All statutory approvals should be obtained by the end of this phase.

ii. Bill of Quantities: Itemizing and scheduling all the elements of the design required to complete the works. This is not only including the items indicated on drawings but also other conditions required to carry out the works for project like site establishment.

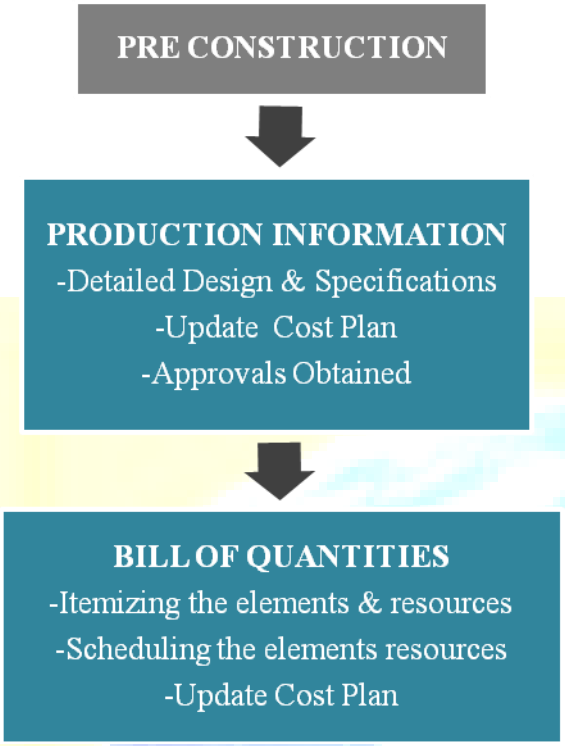


Figure 5: RIBA Plan of Work: Pre Construction

Figure 6: RIBA Plan of Work: Construction

d. Construction: The project on the site will happen in this phase which is divided into two stages-

i. Mobilization: Production information issued and site is handed over to the contractor.

ii. Construction to Practical Completion: Programming the work in accordance with the contract and commencement of work on the site. Administration of the building contract to Practical Completion. Further information supplied to the contractor as and when reasonably required.

e. Post Construction: Final inspections are made to ensure specifications have been met. In addition, the final account is settled. After that the building would be handed over to the client. This phase can also be called as Feedback as review of project performance would be done.

Figure 7: RIBA Plan of Work: Post Construction

1.3 Problems identified in the current scenario: Koskela (1993) states that

"The chronic problems of construction are well known: low productivity, poor safety, inferior

working conditions, and insufficient quality."
This was true in the case of Firm X also.
Table 1: Problems identified in Firm X:

Problems	Explanation
Complexity	The first and basic problem lies in the fact that each and every process was too complex and perceived in a difficult way even though it could have reached by simpler way. Too much details, people and process involvement always made the situation chaotic and sometimes very difficult to manage.
Implementation	The work commencement on the site general y takes place weeks after contractor wins a bid. This can be a major issue on time-factor considering the fact that project has been underway for years, and maybe designed for one year or so. Hence, the initial implementation system is not clear.
Flow of Work	The flow of work was not very smooth to begin with. Even if things were being planned properly at initial stage, there was no guarantee that it would be handled in the same way.
Production Issues	If problem was identified while work is being progressed, either it used to be neglected (if it was very small) or used to be completed with too much time given into it. Sometimes, such problems were left to be handled later on. Similarly, in India, people still believe in traditional method of construction and give very less thoughts towards new ways of construction.
Organizational Issues	Deadlines were followed but not strictly. Rules were made but not rigorously

Communication Issues	The whole construction industry is based on the idea of Team Work. One of the main enabler for team working is communication. Thamain (2004) figured the enabler's hierarchy for team performance: "Effective communication; trust, respect, and credibility; overall team performance; and, interesting, stimulating work." Lack of communication and collaboration in the atmosphere does show up in the work time and again and so was true in cases of many projects being handled
Waste in Construction	The most important of all was waste of any and every kind. All kind of wastes were being found during the construction period of some or other projects handled by Firm X. Some of these were right there in front and some were hidden only to be resurfaced later after the damage being done on the time and cost factor of the project.

1. Further detailing out above mentioned problems is the lack to update. Looking as an outsider, the company looked very manageable and systematic, but as an insider, there was the realization that everything was just like a doormat or decoration on the wall. The constant planning and management system for construction from initial site-setups, execution, and material management to removal of temporary works was always on paper and looked extremely good. But when it came to executing it on site, the list would not be updated with new changes and hence not followed.
2. Furthermore, if the master plan is being used, the work break down into weeks and months were not followed properly, specially the weekly work used to go for a toss. The compulsion to finish off work in week deadline sometimes made whole working scenario complete mess and work not achieved to quality level due to frantic rush.
3. Controlling and management of resource is major issue. Ohno (1988) identified the following seven wastes:

   i. Waste of overproduction;

   ii. Waste of correction;

   iii. Waste of material movement;

   iv. Waste of processing;

   v. Waste of inventory;

   vi. Waste of waiting;

   vii. Waste of motion.

The first five refer to the flow of material, the two last ones to work of men.
Overproduction of material is common wastes, wherein it leads to excessive storage and lead time. Many a times, products do get damaged but it is still practiced to be on the safer side. Even though Firm X was in constant touch with the client during project phases, so that design does not suffer any time and does not lead to mistakes in drawings while implementing it on site. But still somehow or other there used to be some lack of information, insufficient details which lead to waste in time correcting it and executing it on site.

Besides above mentioned seven wastes by Ohno, there could be other wastes which should be taken care of during the course of the project, for example: the waste of pollution. Similar is the case of using excessive energy or power during construction considering the fact that energy is big concern in the world today. Consideration should be given to wastes of spaces, both in design and construction site.

4. Design-Build projects were sometimes undertaken. But the profitability of such projects were oddly lower than average. Maybe it was because of the fact that the country where Firm X was being situated haven't real y explored this type of working method and due to that the whole system of working was total y chaotic under the supervision of project management, with a site background. The whole idea of integrating both design and construction sometimes became too much to handle and this can be partially blamed to the very laid-back attitude in organization during such project.
5. At the end of the day, it was all about group of individuals coming together and performing. Walker (1997, p.42) reviewed team performance as:
"Team performance appears to be a complex balance of the management action, undertaken through planning, co-ordination and communication, to aid and inform decision making. Various team members employ different levels of task or people oriented management styles and different organizational responses in terms of rigidity or flexibility towards rules and regulations. These are undertaken in response to situational factors of different groups respond in different ways depending on their management maturity and/ or willingness, as well as the perceived level of complexity of the tasks they face."

Maybe, Firm X did lack in this department and hence there was chaos in other situations most of the time. So resolving this issue was definitely needed.

Part 2

Lean Principles

2.1 Introduction: The last two decades have witnessed numerous improvements in performance of a manufacturing. For example, Toyota Manufacturing System which came out as a winner with adoption of new method of working using less of everything and more profits. Alarcon (1997) supports this idea by stating that "all these improvements have not been the product of a radical or sharp change of the technology but the result of the application of a new production philosophy

which leads to – Lean Production".

First and foremost lean does not mean little at all. As far as describing the word 'lean', let's take a general day to day example of a lean body. A person with lean body means someone who is healthy with less or no fat at all. Similarly in construction as comparing it to human body, fat is equivalent to waste, whereas health can be value. Therefore Lean Production in Construction in simple terms is philosophy to decline waste in production companies as described by Melles (1994).

2.2 Goals: Talking about goals of lean thinking, Ballard and Howel (1998) further adds that "the goal of lean thinking redefine performance against three dimensions of perfection:
a uniquely custom product,
delivered instantly, with
nothing in store.
This is an ideal that maximizes value and minimizes the waste."

At the end, it is all about keeping the client happy and giving them total value for their money. The idea and definition of value does change from client to client and on situations. The idea of adding value in a project should be throughout the project, in al the stages.

2.3 Principles of Lean Thinking: In order to achieve lean production, there are number of principles on which it is based upon. Womack and Jones (2003) describe five ideas of Lean as:

1. Value Specification

As Womack and Jones (2003, p.16) mentions

"The critical starting point for lean thinking is value. Value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of a specific product (a good or a service, and often both at once), which meets the customer's needs at a specific price at a specific time."

It is important to understand the product and the need of the customer. Then follow it by measures to monitor the results.

2. Identify Value Stream

Identification of the steps needed in value creation is important as it will help eliminating all the non value activities throughout the value stream.

3. Flow

Aim for one piece of continuous flow. It can be done after eliminating waste and making value stream compact and tighter and in integrated sequence.

4. Pull System

Instead of pushing your product towards customer which often becomes unwanted, the pull system should be approached. Waller (2003, p.460) says that the client's order triggers a demand. This

demand pulls the required product through the supply chain from distributing, manufacturing, back to purchasing. Just in Time is a major example of Pull System.

5. Perfection

After implementing above lean principles, strive for perfection in all the areas. Creating zero defects throughout the process and increasing rate of flow should be practices all the way; hence aiming for aiming for excellence.

Liker (2004) recommends 14 Lean Principles adopted by Toyota automobile for their manufacturing process. These principles are broadly categorized into four main headings:

1. Long Term Philosophy;
2. Process Improvement;
3. People and Partners Development; and
4. Continuous Improvement and Learning.

Within these four dimensions Liker mentions about the entire approaches one can adopt to eliminate waste and add value to the product. A deeper implementation happens when the Lean culture is embedded in employers and employees culture. Moreover, he adds that it is important to keep the company's identity during the implementation of Lean since every company is unique and should search for the most appropriate set of tools according to the company's Context: the case being a construction company, i.e. Firm X in this context.

Part 3

Implementation of Lean Principle in Firm X

3.1 Why implement Lean in Firm X:

Ballard and Howell (1998) mentions that

"Lean thinking is a new way to manage construction."

Lean Construction website describes it as a production management-based approach to project delivery: a new way to design and build capital facilities. It further highlights the result of Lean Construction:

- The facility and its delivery process are designed together to better reveal and support customer purposes.
- Work is structured to maximize value and to reduce waste.
- Efforts to manage and improve performance are aimed at improving total project.
- The performance of the planning and control systems is measured and improved.

Implementing Lean in the construction industry is a tricky business as it requires deep thinking and understanding of goals to be achieved and techniques to be followed. There is no right or wrong formula to implement Lean as there is no fixed formula for it.

3.2 Lean Principles in Firm X: The best would be going through the principles of Lean suggested by Liker (2004) and then extracting out the result by figuring out which works and which does not work for Firm X.

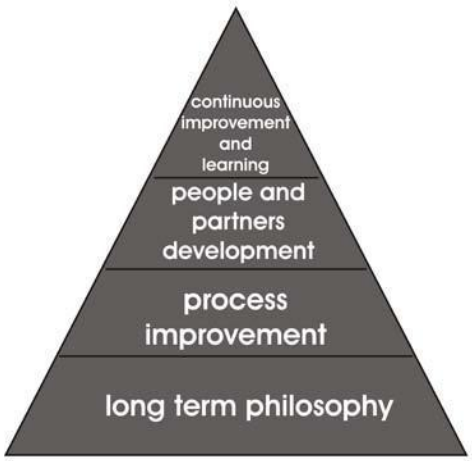


Figure 8: Toyota Way Principle Model- Liker (2004)

Long Term Philosophy:

Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals: Firm X really need to work on this principle. Agreed that everyone is out to make money and profit in their business, but also equal y important is to growing of organization and having long term philosophy. There are new ways of managing construction coming every year and it is important to build up rapport with the client and knowing their needs. So generating value, keeping them in mind and achieving it can start of good relationship for future. This is a philosophical method, which can bind the whole organization together to strive for the best and can be foundation for all the other principle that will benefit Firm X.

Process Improvement:

Create continuous process flow to bring problems to the surface: One of the major issues for Firm X as no work was carried out as planned in initial stages and everything used to be haphazard on the site. Therefore is the need for redesign work processes to achieve high value added continuous

flow. While it is important to create a flow of material and information fast, it is equally crucial to link all the processes and people involved in the project together. Also making it evident throughout the course of project adds unto benefit of organization and to develop it.

Level out the workload (Heijunka): The concept of Muda (waste), Mura (unevenness), Muri (overburden) can be very well adopted for Firm X.

Liker (2004, p.114) describes Muda as "wasteful activities that lengthen lead times, cause extra movement to get parts or tools, create excess inventory, or any result in any type of waiting". Pushing equipment or/and labor in some way that exceeds their natural capacity and overburdening should be eliminated and so does unevenness in the production schedule.

All these are common problem in many construction companies like Firm X. Overburdening results in safety and quality problems and overburdening machinery is a direct cause of breakdowns and defects. Similarly many a times, there is no work for some labour and machines on one day and next day they are flooded with amount of work. Hence, is the need to adopt the concept for leveling out the workload(heijunka)in FirmX.

Build a culture of stopping to fix problems, to get quality right the first time: The idea should be to get the quality right the first time only. It means getting right skilled labour, right quality of material and right procedure to get everything perfect on the first time. If anything goes wrong, the problem should be solved there and then only. The advantages it can bring to Firm X can be using of modern quality assurance and proper people to build right at the first time. It leads to reduction cost in terms of inspection and then repairing. It definitely enhances productivity in the long run.

Use only reliable thoroughly tested technology that serves your people and process: New technology is often dismissed as unreliable; therefore it is better to test it before adopting it whether it is in organizational level, construction or production level of the project.

A construction technique like the use of modular architecture style and pre-fabricated construction can be introduced into Firm X. It is widely known construction style and hence can be adopted with slight modifications making it suitable for the country where Firm X is based upon. The units would be brought from outside and then assembled on the site. Such design reduces on-site build time, maximization in efficiency and precision. It gives flexibility for design and finishes. It nurtures the use of renewable materials and has high energy efficiency ratings and low carbon impact. Also can be incorporated high quality insulation and air filtration. Jefferis and Madsen (2006) further supports this type of construction by stating that this all canbe achieved without much additional cost and it increases comfort while reducing energy costs.

The need to encourage the organization to use such technology should be considered so that everyone knows what and why they are doing; looking at new approaches to work. Such techniques can improve the flow of the processes.

People and Partners Development:

Develop exceptional people and teams who follow your company's philosophy: It's said that getting right people for the work is half the battle won; the idea is to have a strong team working approach. The focus should be on creating a Balanced Team. Belbin (1993) describes it as when all team members know of their roles and acknowledge the existence of other team members and their roles too; this leads to Balanced Team; which is divided into four necessary roles: Leading, Doing, Thinking/ Problem Solving and Socializing/ People roles.

In addition to that, all the team members of a project or organization should have focus on goal achievement; wherein teams are built and teamwork is achieved. Here comes Tuckman (1965) idea of Life Cycle of a Team; where every team goes through the process of Forming, Storming, Norming, Performing and Adjourning.

This one is tricky part of team performance as this one leads to end product and whole success of project is dependant of this attribute. Any kind of mismanagement or blockage might lead the team to Adjourn in any stage and start again afresh which happened a lot in other projects inFirm X.

Therefore is a need to develop exceptional people and teams. But this is not a quick process, it might take days or months to implement and 'motivation' should be the keyword; focusing on rewards, pay, security, etc.

Respect your extended network of partners and suppliers by challenging them and helping them

Improve: Another big disadvantage for Firm X was though it was highly respectful towards clients; it did not share cordial relationship with suppliers. This holds true to maximum construction company in India and it maybe because of the fact that there is still the presence of Power Distance. Hofstede (2001) mentions it as human equality, for example inequality on the basis of prestige, power or wealth even. India would feature high on Power Distance and similarly Firm X too. Therefore, there is never same set of suppliers for each project. Respect and dignity should be given to each and every individual involved in the project.

Continuous Improvement and Learning:

Go and see for yourself to thoroughly understand the situation: As described earlier as Power Distance, very rarely a top management would go and see any kind of problem happening on the site.

For the improvement of process, everyone from top to bottom in an organization should be aware of the problem and are expected to see it to know it. Because... "without experiencing the situation for yourself—Genchi Genbutsu, you real y do not have an understanding of how it can be improved". If incase, the top management is not able to personal y 'go and see' the problem, a trusted advisor should be hired to check al these shortcomings and report it.

Become a leaning organisation through relentless reflection and continuous improvement: This applies many of the preceding principles to the organization as a whole. It is aiming for improvement in the project process considering everything that one does and seeing whether it could have been done better. Besides in Construction Phase, it can be well adopted into Feedback

phase of construction project as it is about reviewing the completed project and judging and finding out what can be better in next project; i.e. use of hansei (reflection) to identify shortcomings and countermeasures to avoid it. A problem solving technique is presented which elaborates on the 5-Whys process to determine the root cause. It includes:

1. Initial problem perception
2. Clarify the problem
3. Locate area/point of cause
4. Investigate root cause (5 whys)
5. Countermeasure
6. Evaluate
7. Standardize

This can fit completely into Firm X's construction projects and well implemented. Designing of process should be done which requires almost no inventory. This makes time which is wasted and so does resources visible and hence continuous improvement process can eliminate it. Also learning to standardize the best practices adopted in previous project can be helpful for new projects rather than restarting it up with new organizational structure.

3.3 The 5-S: Liker (2004) describes the 5-S as Seiro(remove), Seiton(organize), Seiso(keep clean), Seiketsu(standardize) and Shitsuke(respect the rules). Each and every S has its own purpose.

Seiro's philosophy is removing any unneeded cluttering in the operation area as it can slow down the activity.

Similarly organization of items is a way to reduce time for later activities (Seiton) and so is keeping clean (Seiso) and standardization (Seiketsu). A clean working area not only is better tolook at but also helps in quality work, at least psychologically. Respecting rules allows flow of work in a required manner, hence the fifth S.

This can not only benefit Firm X's project not only on construction and site level but also on management level as it implies on being rigorous, organized and efficient during the whole course of the project.

3.4 Just in Time: Vonderembse and White (1996, p.639) define Just in Time as a philosophy of operation that seek to maximize efficiency and eliminate waste in any form, influencing all parts of a company, including purchasing, engineering, marketing, personal and quality control and even data mining the relationships along the company, its suppliers and its customers.

Fundamental Concept of JIT

Flow Manufacturing

- Make materials flow as continuous, uninterrupted flow runs all the way from suppliers to final customers.

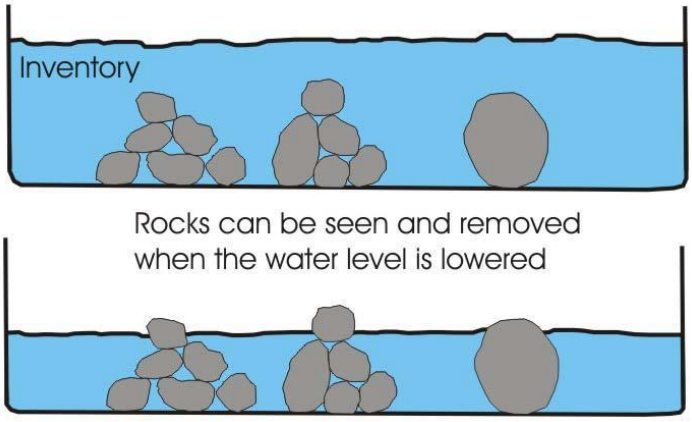


Figure 9: Flow Manufacturing- Vonderembse and White (1996, p. 641)

Simplified Production Process

- Use of simple production processes like reducing set up time, and using one simple machine for each part instead of trying to do all parts on one complex multipurpose machine.
- Easy movement of machines, getting rid of automated handling system and moving the workers so they are in close proximity.

Uncovering Problems buried by Inventory:

- While inventory reduction is most obvious aspect, its most valuable benefit is that it forces a company to uncover problems and inefficiencies in its operations.

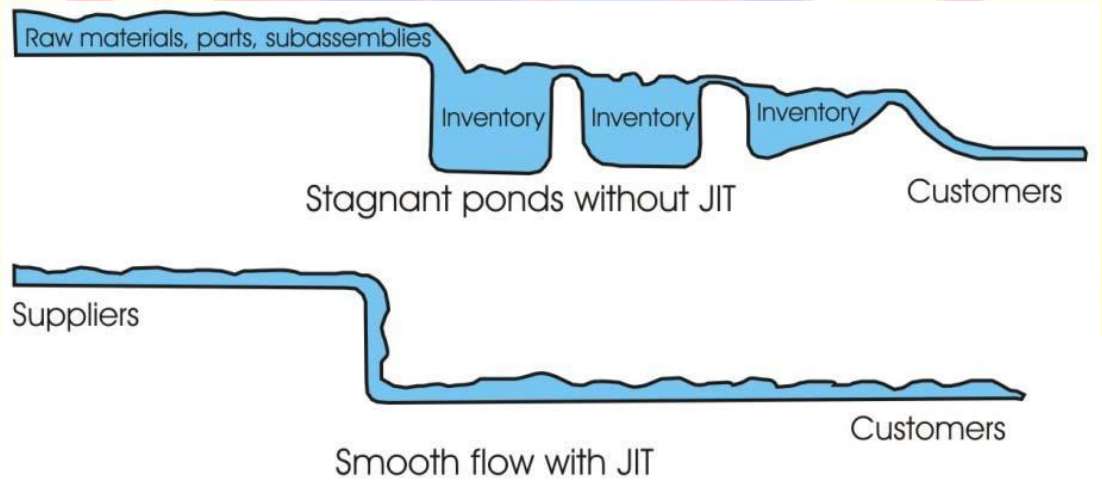


Figure 10: Uncovering Problems buried by Inventory- Vonderembse and White (1996, p. 642)

An Emphasis on Quality:

- Quality is of upmost importance, considering the fact that it can halt the entire process because of one bad part, and moreover parts are manufactured in large batches.

- Many company implements a total y quality management program.

Improvement as an Organizational philosophy:

- Constant urge to improve. Uncovers many problem and finds better way to do everything while reducing waste, smooth flow and improving efficiency.

Pull System:

- The client's order triggers a demand. This demand pul s the required product through the supply chain from distributing, manufacturing, back to purchasing.

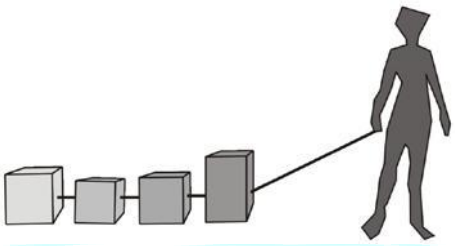


Figure 11: Pull System

How JIT works in Firm X: Just in Time is all about having right amount of people for right work at right time. All the above mentioned features of JIT would help a great deal in Firm X. Besides these any set up times would be significantly reduced. Even the flows of goods from warehouse to shelves would improve. There would be increased emphasis on supplier relationships. Bringing right amount of people means hiring right employees and also employees who possess multiple skills are utilized more efficiently. Besides these focus can be on goals usually set out as part of JIT implementation (Waller 2003):

1. Zero defects- Implies in all materials, machineries and products, meaning suppliers respecting all specifications and quality control before delivering.
2. Zero breakdowns- Checking that all equipment, tools and machines are in perfect running order during construction phase. Regular schedule of preventive maintenance required.
3. Zero inventories- Stocks of materials are almost zero. Though in practice this isn't desirable but at least unnecessary inventories can be minimized.
4. Zero delays- All milestones and review dates are respected throughout the course of the project; keeping in mind the schedules have to be realistic and agreed during planning phase.
5. Zero accidents- It all depends upon how good the management is; properly serviced and maintained machines and site, as well as necessary training is needed since this can lead to many aspects besides being threat to life, also at delays, costs, etc.

3.5 Agile Project Management: In this ever changing world, nothing is permanent. New discoveries and technologies are making its way out every day and in every possible form. These changes make life easier and complicated at the same time. Therefore, it is important to have an open mind and to experiment around.

It would not be wrong to say that The Construction Industry is affected and also benefitted with these ongoing changes around. If we hear about credit crunch some day, we also hear about upswing in market another fine day; it's become that unpredictable.

Owen and Koskela (2006) mention that agile production techniques are essentially a further development of lean thinking. Where lean production is a continuous aim for delivering a product to meet its client's demands as they arise, it assumes that demand for a specific product remains relatively constant. Agile applies the same tools and techniques to its production systems, but builds in enough flexibility to meet varying demands for a range of products, while maintaining a competitive edge and achieving profitable returns.

Agile simply means being quick and well coordinated; so in construction terms it means having such a structure which can quickly face uncertainty and adapt to changes.

There ingredients of Agile Manufacturing in accordance to which Firm X can put its best forward in this competitive world are:

1. Organization: Flexible enough to react towards changes in demand and market forces. This holds true especially in today's scenario of credit crunch. At the same time, it should maintain its competitiveness and profitability.
2. Human Resources: Recruiting highly skilled and knowledgeable individuals to work in Firm X will definitely act as an asset to the company.
3. Technology: New innovative technologies are being developed on day-to-day basic. So getting to know it and using it can keep a company well up in market and also reactive towards fluctuations and demands as such.

The advantage of adopting Agile Project Management however lies in the factor of Risk.

Organizations are often risk averse; sometimes huge disputes are raised in construction industry on the topic of risk and risk management. Also sharing of risk is a sensitive issue amongst all stakeholders. The agile way is that risk is passed to whichever party is most capable of resolving it, irrespective of initial contractual relationships. This can benefit Firm X in great deal. No chaotic situation arises and the responsible party will try handling it in its' best possible way.

3.6 The Last Planner: The Last Planner (LPS) was designed by Ballard and Howell and its functions as stated by Fialo and Revelo (2002) includes: "productive unit and work flow control, and completing quality assignments. In addition, it makes it easier to get to the root of the problems and to make timely decisions regarding adjustments needed within the operation, in order to execute actions opportunely, thereby increasing productivity".

The whole idea of The Last Planner is to make work ready to be performed so that it can be finished without any interruption (Ballard 2000). This system not only facilitates one's own work but improves the productivity on the site.

Application of The Last Planner in Firm X:

Whenever there are any weekly tasks to be completed, the problems arises from the initial starting

of the project itself. Then such problems are added up during operations and completion of the tasks too.

The Last Planner tries to eliminate those problems by:

At the beginning of the task: look ahead planning, making ready and continuous improvement.

During the task: phase planning, ready making and conversion & commitment.

Task completion: checking tasks completion & finding causes at the end.

Now looking at the benefits of each of these would be:

Look Ahead Planning- A effort towards identifying and eliminating any kind of restrictions for starting the tasks. This can be done in the form of Master Plan and then subdivided into monthly and weekly plan during the initial stage of the project and being updated as the project progresses.

Making Ready- It is about making tasks ready so that they can be done when the right time comes (Alsehaimi 2009). Therefore is the need to check the resources: materials, labours and equipments beforehand. Only tasks with all arrangements available are started. This willmaintain smooth work flow during the completion of task and reduces uncertainty.

Continuous Improvement- Contributes to the reduction of starting problems on longer term (Koskela 2009). Once the comfort zone is set up for some task, it can be easily achieved next time with better performance.

Phase Planning- Division of project into several phases and identifying parties involved in it and hence ensuring that the best order of tasks is determined by clearly understanding the plan.

Ready Making- This one is about weekly tasks; wherein arrangements for any tasks are being checked on weekly basis rather than just at the starting of the task. It reduces sudden uncertainty and risk issues.

Conversion & Commitment- No unplanned tasks should emerge in between during the week and it may harm and interfere with the current tasks being done on weekly planning. Weekly planning should be totally commitment based with regular communication between the parties involved.

Checking tasks completion & finding causes at the end- Measuring the productivity of the tasks and reviewing properly whether the tasks went wel or not. If it went wel - importance of improving the performance; if it did not go wel - analysis for the reason of failure and work on improving it.

Part 4

Applying Lean in Firm X

4.1 Recommendations: Implementing lean is also not without risks content. Waller (2003, p.483) does states that it requires much disciplined workforce, minimum inventories and should be severely systemized. Hence is the need for nature of change in the organization for Firm X. Ballard and Howell (1998) identified the generic recommendation made by Womack and Jones (1996) in *Lean Thinking* for the application of lean principles within an organization and can be adopted for Firm X too.

Table 2: Applying Lean in Firm X

Recommendation	Explanation	In Firm X
Find a change agent	Having such a person in the organization that makes things happen and work; someone with the quality of leader who gives confidence and courage to cause action and strengthen lean implications. Equally important for the change agent to have is understanding and knowledge about working and objectives of lean and its principles and how it can apply to the organization and nurture. Also, shifting from traditional thinking of construction as it happens to new methods needs convincing and power and change agent should possess all these attributes	As an example as mentioned above about Power Distance being high in India; whereas Lean principles talks about equality and respect for all. Therefore, the change agent should be strong enough to imply such principles in the organization.
Get the Knowledge	To implement lean; enough knowledge and learning about it is necessary and can be gained more by practicing it along the way. With the introduction of IT facilities around the world and many books being written on lean; acquiring knowledge has become very easy. Gaining knowledge about lean is easy to achieve; there are lots of sources of information and many case studies, although these tend to cover manufacturing activity and not the construction industry.	To make the organization know about lean construction and impart knowledge seminars and workshops can be conducted.

Recommendation	Explanation	In Firm X
Find a lever by seizing a crisis or creating one	Any good potential project should be the starting point of implementing lean. Alternatively, it can be in the middle of going well running project so that it reveals the weakness of current systems and power of lean thinking.	Right now is recession period and lean can be a method to make Firm X fit enough to come through credit crunch time.Though initial setup and imparting knowledge as discussed earlier can be consuming, therefore lunch time small presentations can be hold for people and partners of Firm X.
Forget grand strategy for the moment	Taking small step by step will conquer the big opportunities in the future. Lean is a systematic approach; hence maybe tackling of implementing lean on small areas of projects initially will point out its benefits; than jumping into it in full force.Slowly and steadily, lean principles can be introduced in multiple doses along with the upcoming projects and checking the result.	Start on with 5-S which deals with disciplined and having clear organization around. It will benefit the employees to work around in the surroundings and initiate their interests towards lean.
Map your value streams	Mapping the value stream will enable in the reduction of waste, the improvement of the process and help encouraging the take-up of and acceptance of lean by those outside of the exercise. In construction value stream mapping cuts across multiple organizations.	Let know the surroundings, clients and supply chain about lean implementation in the firm and show the business cases for its implementation. Wastes can be highlighted and brought out as an important issue and how introduction of lean means no wastes and value for money in the scenario.
Being as soon as possible with an important and visible activity	Adding lean in initial stages of project is a good idea for example initial thinking of procurement options which is an important activity.	Procurement option phase during construction is an important phase as all the details are carved out from the client's brief and crucial decisions are made on how to implement the whole project. In other words, this is the stage when project starts happening under the organization and actual planning takes place. Hence addition of lean can act as a wise decision at this point of project where a reliable planning will demand a strong response as lean

Recommendation	Explanation	In Firm X
Demand immediate results	It is well defined in lean that stretching work is complete waste. Long lead times mean long wait for results; so when implementing lean in the organization it is expected that immediate results are achieved. Asking for wrong results will destroy lean initiative; therefore is need for results at each and every step of project are it on management side or construction site.For example, work of foundation can be divided into smaller categories like water proofing, plinth work etc and demanding immediate results for each items would help in improvements; otherwise many times, backlogs remain.	Use of different value and result measuring techniques to be adopted. For example, having review periods before and after every change in task will maintain this application and achieve a flow of work.
As soon as you have momentum expand your scope	Ballard and Howel(1998) states that "The rate of change is most important measure of lean implementation. If your effort is not causing actions in all corners of the organization, if people aren't finding and making changes on their own, you are off track. Implementing lean always brings more opportunities to the surface."	It is important that each and every individual embraces lean principles in the organization. Then everyone can bring their own touch to it and improve and broaden the knowledge and scope about it.

4.2 Conclusion:

Performing is one task and improving while giving performance is another. Lean Principles just manages to do that. Adopting Lean Principles is all about having continuous improvement in the way things functions and perform. It also reinforces the fact that the customer/ client is important and hence providing them with complete value for their money spent. Therefore, value addition and elimination of wastes is the core of Lean Principles.

The various Lean Principles, Just in Time, The 5-S, Last Planner and Agile Project Management are the new ways for manufacturing and hence adopting these in Construction Industry and make it work is a challenge which is being appreciated al over now. Therefore was need for implementing all these in Firm X, India wherein traditional approach is still considered in all aspects of the construction leading to no development and improvement in the organization. Adoption of such techniques can make the firm stand out amongst the crowd and be an exemplary case.

But equally crucial is the ways to implement Lean ideas in such firms like Firm X, where there is no knowledge about such construction. Therefore, with implementation of Lean, one should also focus on the ways Lean can be introduced into the organizations and applying with hiring a change agent who believes into it.

It is all about welcoming the change, improving performance and getting together of individuals who believe in giving value towards the customers/ clients. As Ballard and Howel (1998) states "Expand your view to consider the construction industry as a system and work to improve performance everywhere. If this advice sounds wrong, it probably means you have not confronted the depth of opportunity and change lean offers you and your organization."

References:

1. Abley, I. and Woundhuysen, J. (2004) **Why is Construction so Backward?**, London, Wiley-Academy.

2. Alarcón, L. (1997) **Lean Construction,** Rotterdam, The Netherlands, A. A, Balkema

3. Alsehaimi, A. (2009) **Last Planner System: An Experience from Saudi Arabian Construction Industry**, In: Integrated Design & Production Module, University of Salford, 27 April, Salford.

4. Ballard, G. (1994). **The Last Planner**, Northern California Construction Institute, Monterey, CA; Available at http://www.leanconstruction.org/

5. Balard, G. (2000) **The Last Planner System of Production Control**, Thesis (Doctor of Philosophy), The University of Birmingham, Birmingham.

6. Belbin, R.M. (1993) **Team Roles at Work- A Strategy for Human Resource Management**, Butterworth-Heinemann, Oxford.

7. Fiallo, M. and Revelo, V. (2002) **Applying the Last Planner Control System to a Construction Project: A Case Study in Quito- Ecuador**, International Group of Lean Construction, Gramado, Brazil.

8. Hofstede, G. (2001) **Culture's Consequences: Comparing Values, Behaviors, Institutions, and Organizations across Nations**, California, Sage Publications.

9. Howel G, Ballard G (1998) **Implementing lean construction: understanding and action**, Annual Conference of the International Group for Lean Construction; Available at http://www.iglc.net/

10. International Group of Lean Construction; Available at http://www.iglc.net/

11. Jefferis, A. and Madsen, D.A. (2006) **Architectural Drafting & Design**, 5th Edition, New York, Delmar Publishers.

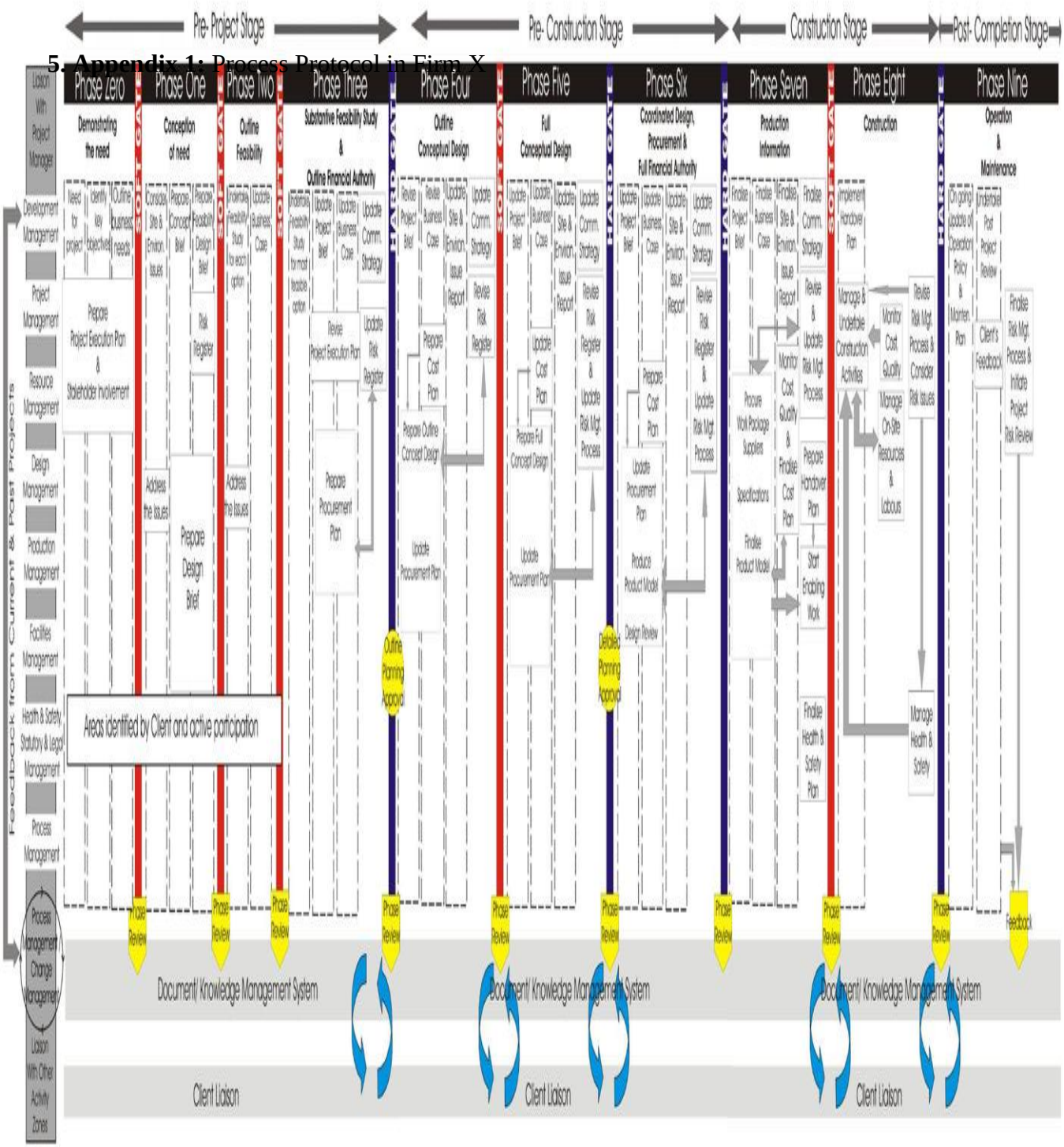
12. Koskela, L. (1997). Lean Production in Construction, **Lean Construction** (editor: Alarcon, L.), Rotterdam, The Netherlands, A.A. Balkema.

13. Koskela, L. (1993) Lean Production in Construction. **The 10th International Symposium on Automation and Robotics in Construction (ISARC),** Elsevier, USA, pp. 47-54.

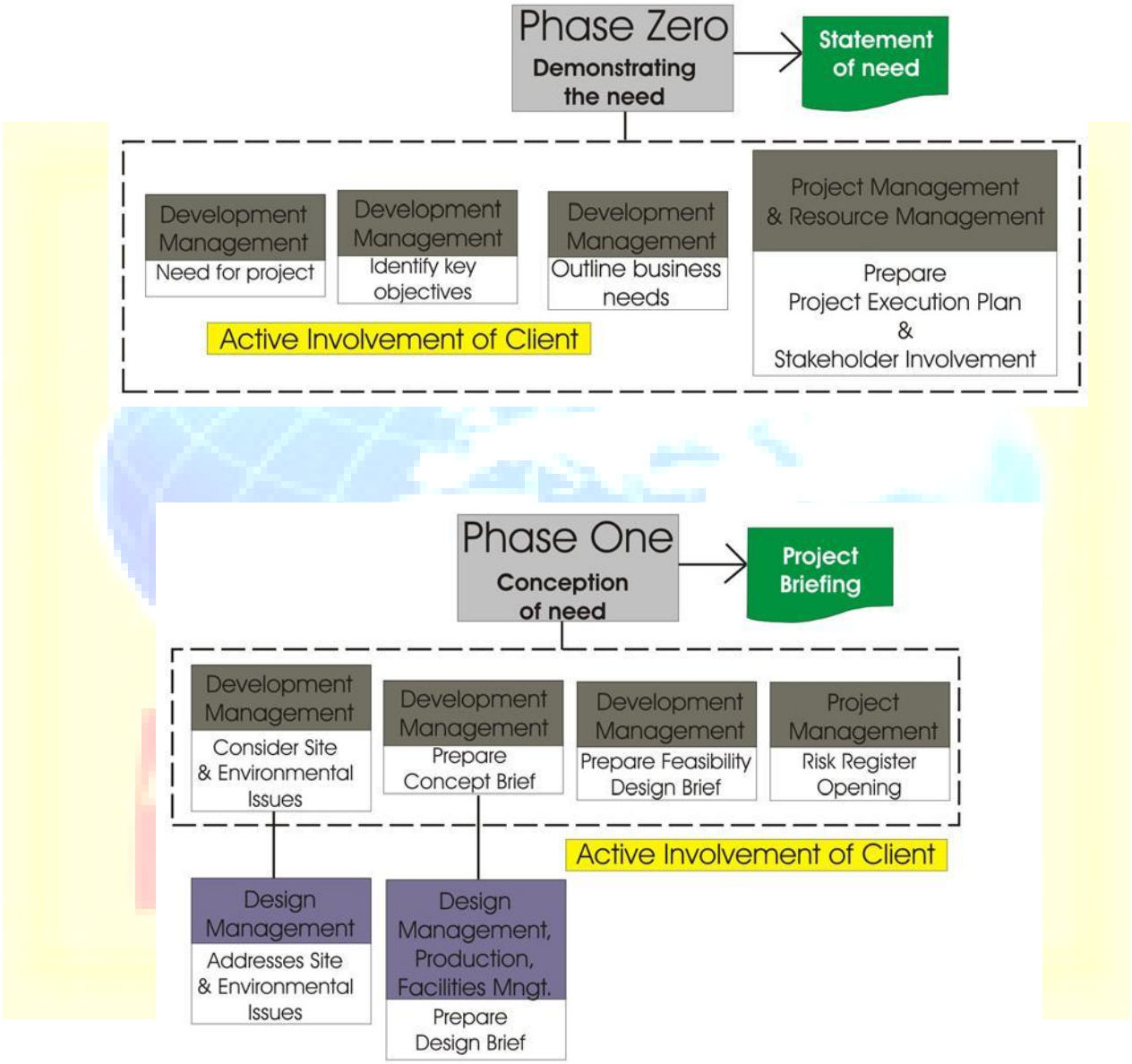
14. Koskela, L.; and Howel , G. A. (2002b) **The Underlying Theory of Management is Obsolete**, In: Proceedings. PMI Research Conference, PMI, pp. 293-302.

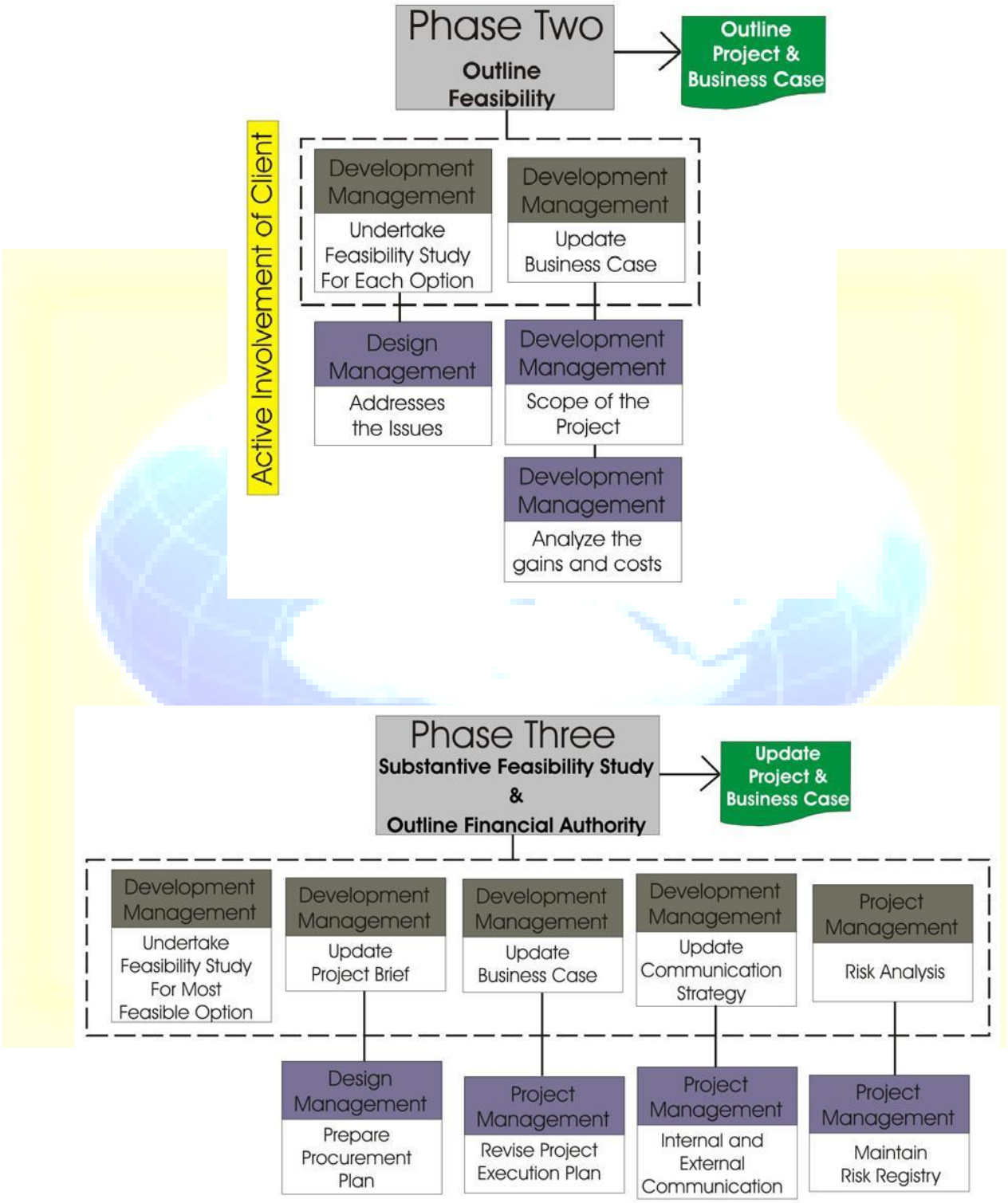
15. Koskela, L., and Kagioglou, M. (2005) **On the Metaphysics of Production**. In: Proceedings. 13th International Conference on Lean Construction (IGLC-13). Sydney.

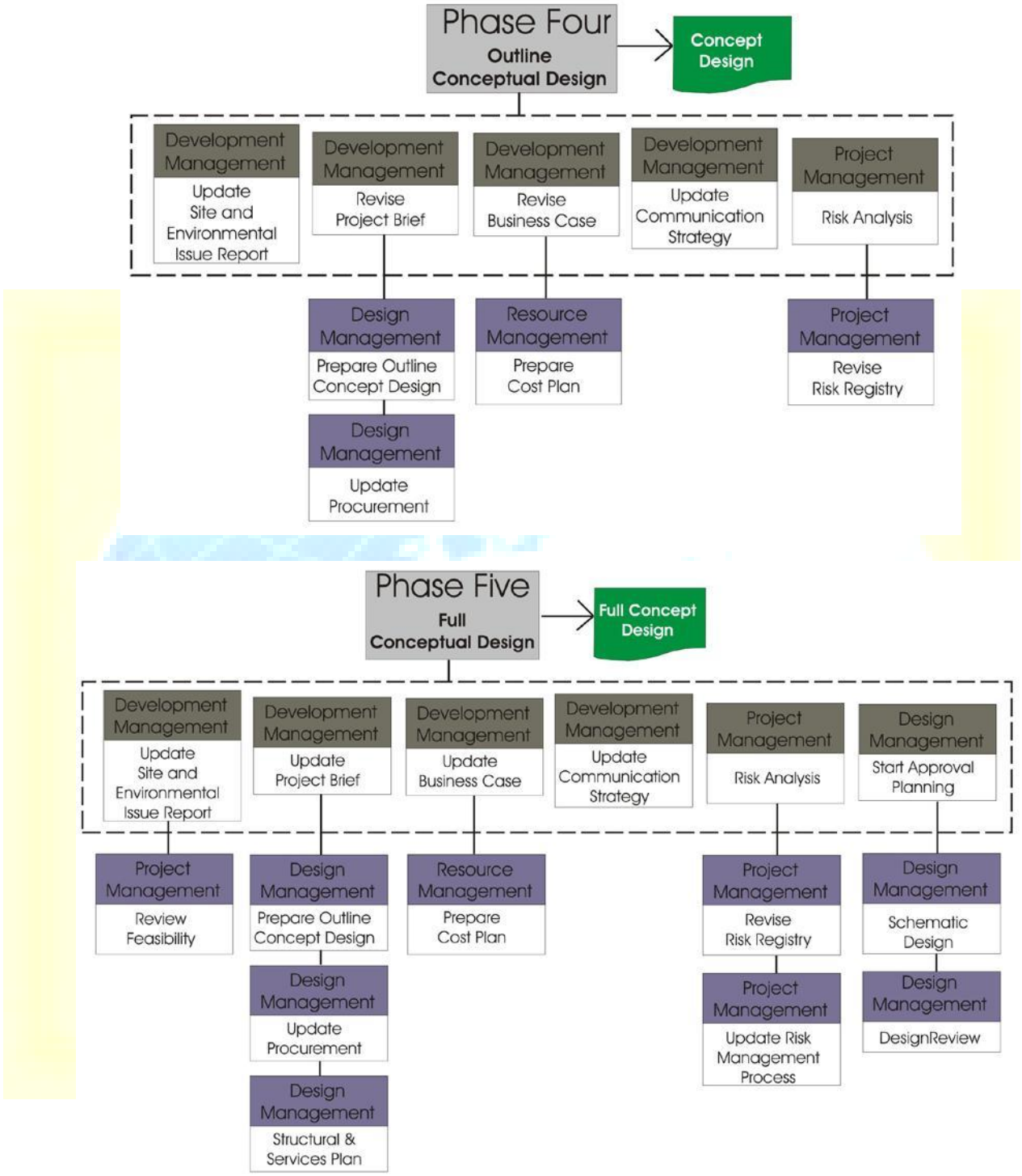
5. **Appendix 1:** Process Protocol in Firm X

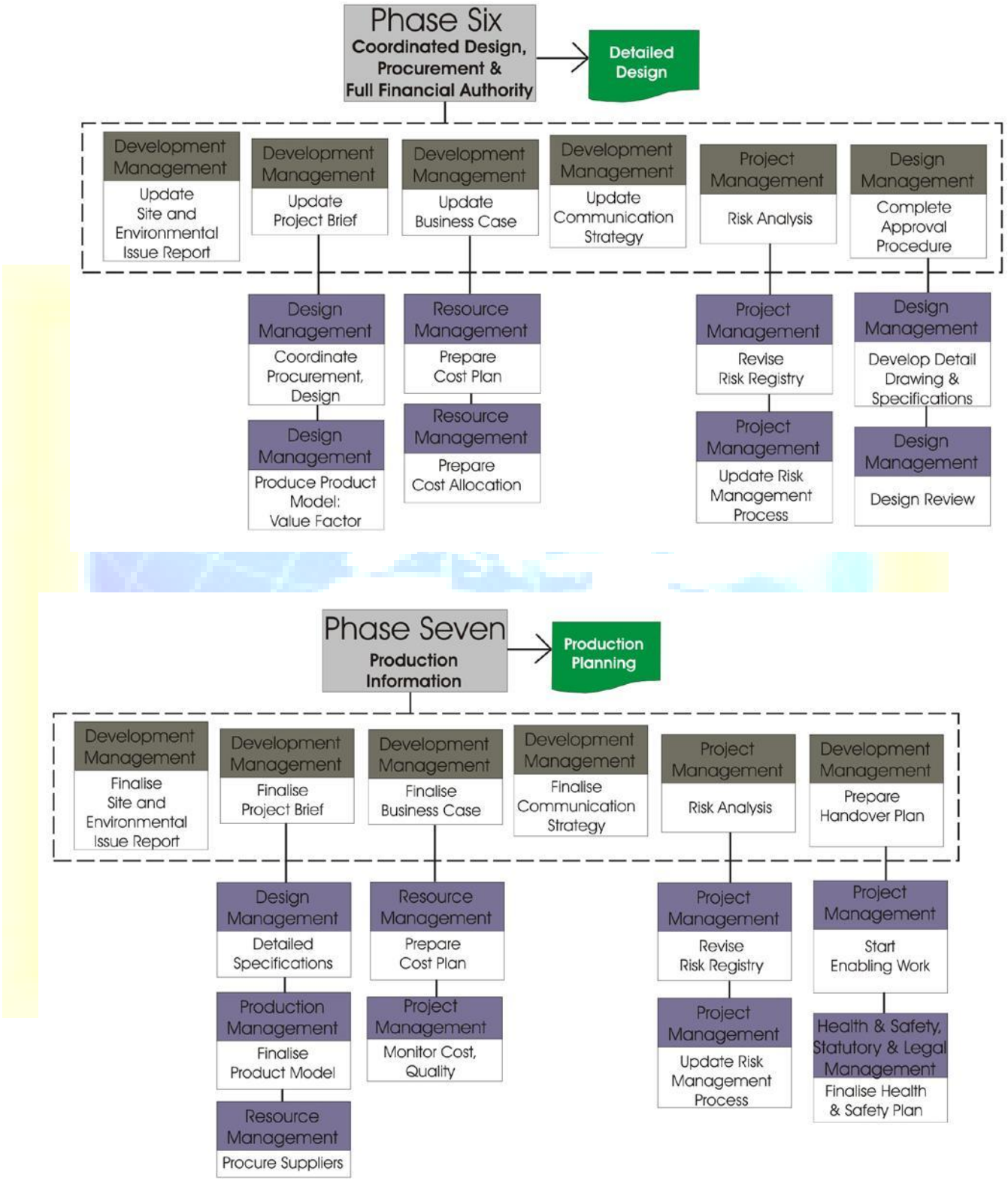


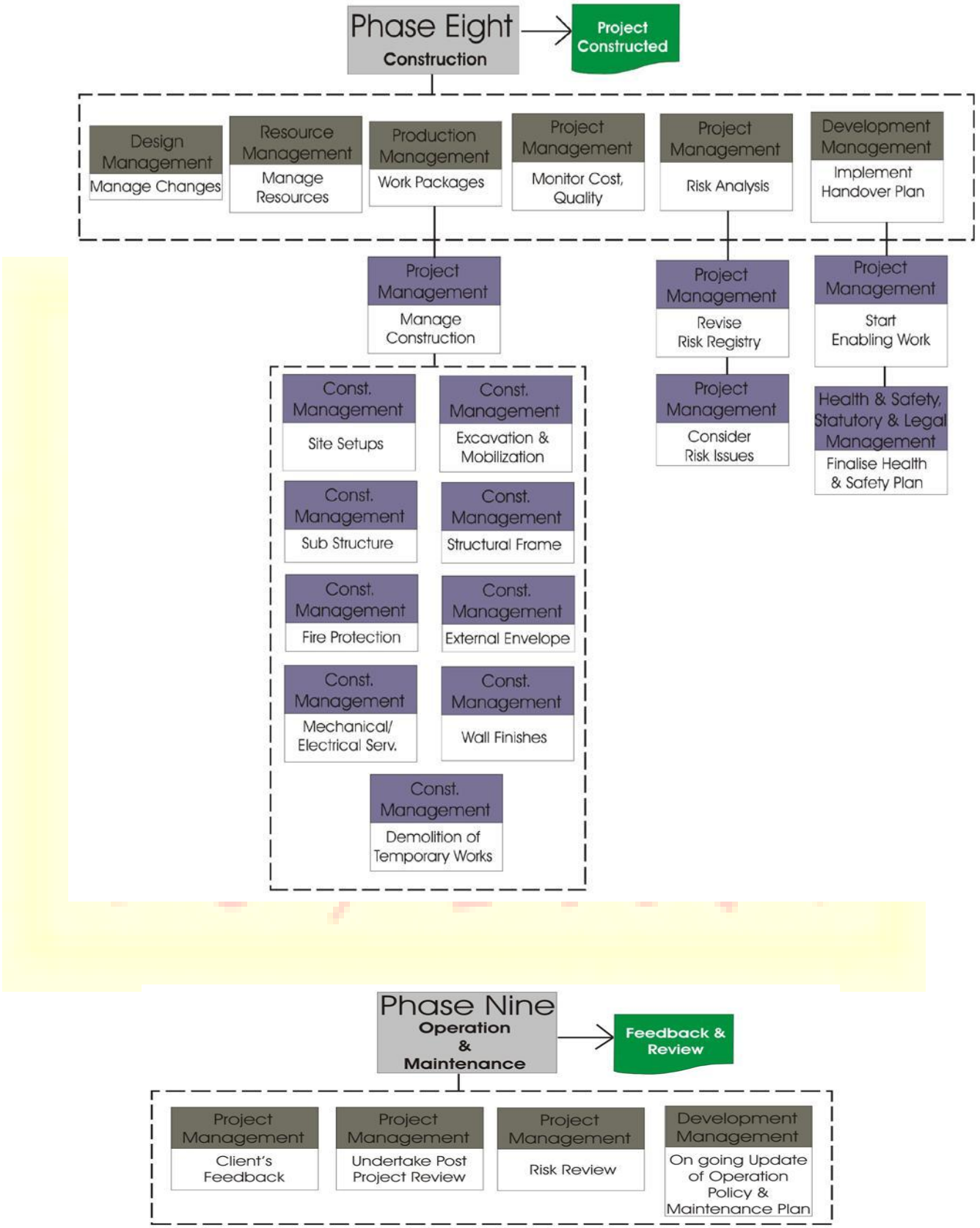
Appendix 2: Phases using Process Protocol




Phase Two
Outline Feasibility
Outline Project & Business Case
Active Involvement of Client
Development Management
Undertake Feasibility Study For Each Option
Development Management
Update Business Case
Design Management
Addresses the Issues
Development Management
Scope of the Project
Development Management
Analyze the gains and costs
Phase Three
Substantive Feasibility Study & Outline Financial Authority
Update Project & Business Case
Development Management
Undertake Feasibility Study For Most Feasible Option
Development Management
Update Project Brief
Development Management
Update Business Case
Development Management
Update Communication Strategy
Project Management
Risk Analysis
Design Management
Prepare Procurement Plan
Project Management
Revise Project Execution Plan
Project Management
Internal and External Communication
Project Management
Maintain Risk Registry


Phase Four
Outline
Conceptual Design
Concept Design
Development Management
Update Site and Environmental Issue Report
Development Management
Revise Project Brief
Development Management
Revise Business Case
Development Management
Update Communication Strategy
Project Management
Risk Analysis
Design Management
Prepare Outline Concept Design
Resource Management
Prepare Cost Plan
Project Management
Revise Risk Registry
Design Management
Update Procurement
Phase Five
Full
Conceptual Design
Full Concept Design
Development Management
Update Site and Environmental Issue Report
Development Management
Update Project Brief
Development Management
Update Business Case
Development Management
Update Communication Strategy
Project Management
Risk Analysis
Design Management
Start Approval Planning
Project Management
Review Feasibility
Design Management
Prepare Outline Concept Design
Resource Management
Prepare Cost Plan
Project Management
Revise Risk Registry
Design Management
Schematic Design
Design Management
Update Procurement
Project Management
Update Risk Management Process
Design Management
DesignReview
Design Management
Structural & Services Plan


Phase Six
Coordinated Design, Procurement & Full Financial Authority
Detailed Design
Development Management
Update Site and Environmental Issue Report
Development Management
Update Project Brief
Development Management
Update Business Case
Development Management
Update Communication Strategy
Project Management
Risk Analysis
Design Management
Complete Approval Procedure
Design Management
Coordinate Procurement, Design
Design Management
Produce Product Model: Value Factor
Resource Management
Prepare Cost Plan
Resource Management
Prepare Cost Allocation
Project Management
Revise Risk Registry
Project Management
Update Risk Management Process
Design Management
Develop Detail Drawing & Specifications
Design Management
Design Review
Phase Seven
Production Information
Production Planning
Development Management
Finalise Site and Environmental Issue Report
Development Management
Finalise Project Brief
Development Management
Finalise Business Case
Development Management
Finalise Communication Strategy
Project Management
Risk Analysis
Development Management
Prepare Handover Plan
Design Management
Detailed Specifications
Production Management
Finalise Product Model
Resource Management
Procure Suppliers
Resource Management
Prepare Cost Plan
Project Management
Monitor Cost, Quality
Project Management
Revise Risk Registry
Project Management
Update Risk Management Process
Project Management
Start Enabling Work
Health & Safety, Statutory & Legal Management
Finalise Health & Safety Plan


Phase Eight
Construction
Project Constructed
Design Management
Manage Changes
Resource Management
Manage Resources
Production Management
Work Packages
Project Management
Monitor Cost, Quality
Project Management
Risk Analysis
Development Management
Implement Handover Plan
Project Management
Manage Construction
Project Management
Revise Risk Registry
Project Management
Consider Risk Issues
Project Management
Start Enabling Work
Health & Safety, Statutory & Legal Management
Finalise Health & Safety Plan
Const. Management
Site Setups
Const. Management
Excavation & Mobilization
Const. Management
Sub Structure
Const. Management
Structural Frame
Const. Management
Fire Protection
Const. Management
External Envelope
Const. Management
Mechanical/ Electrical Serv.
Const. Management
Wall Finishes
Const. Management
Demolition of Temporary Works
Phase Nine
Operation & Maintenance
Feedback & Review
Project Management
Client's Feedback
Project Management
Undertake Post Project Review
Project Management
Risk Review
Development Management
On going Update of Operation Policy & Maintenance Plan