"A strategy for the elimination of failure within construction companies"

by

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April 2012

Contents

1. Introduction

Over the years construction industry in the UK has been placed under scrutiny by several reports, including Latham (1994) and Egan (1998; 2002). These reports suggest that the construction industry is plagued with problems such as low productivity, cost and time over-runs and the value delivered to the client being questionable, often leading to failure of projects. Egan (1998) in his report said *"Lean thinking presents a powerful and coherent synthesis of the most effective techniques of eliminating waste and delivering significant sustained improvements in the efficiency and quality"*. The report also suggested the use of lean as the strategy to achieve sustained performance improvement. Thus, the report looks at lean thinking as a solution to solve the current problems faced by the construction industry.

This report is structured in four sections. The first section tries addresses problems within the construction industry. The framework for the study was taken from a similar study done by Eric Johansen and Walter (2007) in the German construction industry. The second section creates a theoretical foundation to justify the use of lean and its applicability within the construction industry and is largely based on the 'Toyota Production System' as described by Liker (2004). In the third section, the authors have proposed a strategy for adoption within construction companies, which is intended to ensure future projects are more efficient and effective. The strategy has been divided into stages to bring about slow change within existing culture of the company. However, this section emphasises on a 'whole system approach' and is against implementation of individual or combination of tools. The final section describes the tools that are suggested as vehicles of change in the strategy section.

2. Why do projects fail?

Project failure can be attributed to one of, or a combination of, several factors. These include inadequacies in planning and control, execution methods, internal as well as organisational behaviour, procurement techniques, design procedure and inconsistent demand.
According to E. Johansen and Porter (2003), many problems stem from uncertainty and a lack of quality resources. This in turn produces a lack of ownership as well as inaccurate information gathering. They go on to suggest that the hierarchical structure of the long term organisational planning of fuels the failure of the process.
Chapter 2 will break down the aspects of the construction process and analyse the failures, which are likely to occur in each.

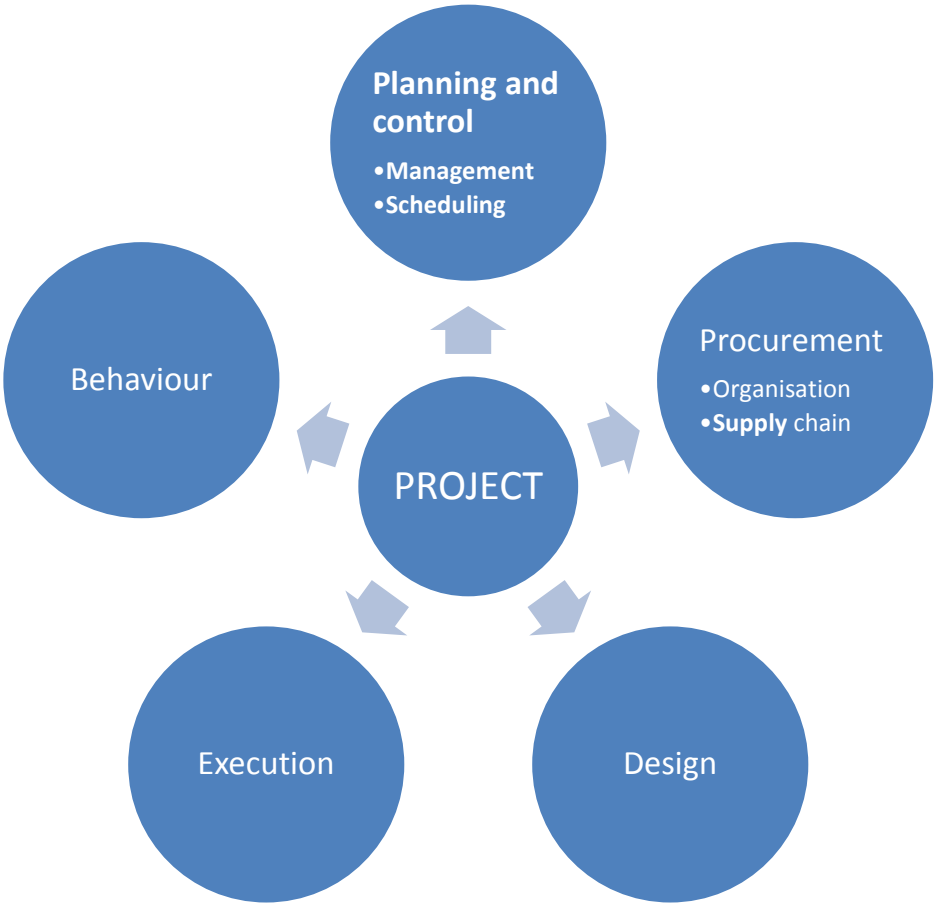


Figure 1:- Aspects of failure within the construction project, adapted from Johansen and Walter (2007)

3. Explanation of failures, relative to current theory

3.1 Planning and control

Due to the multi-party nature of the construction industry, uncertainties increase over the project period. Planning as a tool was envisaged to reduce these uncertainties, manage activities on site and increase transparency of the process.(Chua, Jun, & Hwee, 1999). The traditional process breaks down activities into final products or intermediary products to be delivered. These activities are then arranged in the most efficient way by taking into consideration availability of resources and information available. This is a characteristic of the critical path method (CPM) that is widely used in the industry for planning purposes. However, this method has inherent flaws in so far as the process relies on implicit assumptions. Chua et al. (1999) describe them as management, preparation time and completion on time. The above assumptions expose hidden activities that are contained by the flow. These hidden activities sometimes assist the process of the development of the product, while other times it just adds to the waste. J. Liker (2004) suggests that waste should also include non-value adding activities. Akinci, Fischer, and Zabelle (2000) look at the increasing demand from the industry to build faster and cheaper. They suggest that this leads scheduling of additional activities concurrently, which leads to addition of resources to complete the project as per schedule. This leads to conflicts for space by the various parties involved in the process. They further suggest that efficiencies losses to the tune of 65% occur on site due to congested work and 58% due to restricted work.

The management/ control of these plans remain a question. With the involvement of multiple service and product providers, management of operations gains far more importance to avoid non-value adding waste to occur on site. At the moment design, partnering and quality assurance are the preferred tools. Traditional tools based on financial performance continue being widely used. (Lantelme & Formoso, 2000)

3.2 Execution

Koskela (1992) recommends that the construction industry needs to recognise and adopt an outlook which sees the construction process as one of flow which can be managed and improved (reduced).

Disjointed supply chain

Using traditional methods of construction, up to 90% of work is executed by sub-contractors (Dubois & Gadde, 2000; 1992; Segerstedt & Olofsson, 2010) with main contractors often taking on a construction management role. This means that the project organisation becomes a complex chain of conversions and non-value-adding activities (Koskela, 1992).

Briscoe and Dainty (2005) argue that a more integrated supply chain is needed, not only to bond the client more closely to the main contractor, but also to enhance the collaboration further down the chain at the subcontractor and supplier levels (Hartmann & Caerteling, 2010).

Management of the individual links in the chain needs to facilitate improvement in the flow of information, as well as the production (conversion) and development of the product (Common, Johansen, & Greenwood, 2000).

Poor flow of information and the failure to meet client's expectations

Poor flow of information usually starts from the client and works its way downwards due to the lack of collaboration created by the disjointed supply chain. Early involvement of the clients is not enough to ensure satisfaction with the end product. Instead, a continuous relationship must be maintained in place of the temporary ones. In order to supply the client with what he wants, downstream players need maintain an understanding their needs (Eriksson, 2010).

Failure, like success, is often calculated through the pure measure of time, cost and quality, which is not necessarily the key factor in determining the satisfaction of the customer.

Temporary network

The temporary organisation mentality creates uncertainty throughout the supply chain, and can inevitably result in longer lead times as a habit of risk aversion brought on by a lack of trust. Briscoe and Dainty (2005) point out that it is normal for main contractors to frequently change suppliers, make late payments and withhold strategic planning information, fuelling the fires of distrust and creating a divide. Empowering contractors and suppliers to take some control of the project is essential in order to cement partnership type feelings (G. Ballard, Harper, & Zabelle, 2003; Eriksson, 2010) whilst ensuring fair and equitable rewards, such as gain/pain arrangements (Eriksson & Pesämaa, 2007; Khalfan, McDermott, & Swan, 2007).

Supply deadlines and Delays

Material supplies are generally scheduled months in advance, and often with little room for change due to lengthy production times for components. This rigid planning can have the adverse effect of creating stockpiles of goods, and cannot easily facilitate progression and improvement ahead of schedule.

Despite the instinct of sub-contractors to include additional lead times and lag to time schedules, delays happen. With rigid master schedules to adhere to, delays accumulate and with no mechanism for rectification must ultimately result in failure on the time scale.

Unforeseen events

Inclement weather and force major, whilst expected to cause disruption, seldom have contingency plans attached. The uncertainty of such events often leads to contingencies being neglected, allowing for potential failure.

3.3 Design

Design is often so detached from the actual construction process that buildability issues often force continuous change (waste) throughout the project schedule. In addition the designs themselves may pass down through their own supply chain from architect to engineers and

specialists before arriving at the contractor (Common et al., 2000). The process of design should therefore be adapted to facilitate a relationship with these other disciplines of construction. In essence, it needs its own flow to run alongside those of material supply and work (Koskela, 1992).
Failure to involve the client at an adequate level during execution stages as well as the design stage often leads to the finished product not meeting the clients overall expectations of the project.

3.4 Procurement

Traditionally, construction procurement typically involves multiple companies bidding for aspects of the project through a system of competitive tendering. This process based model has the effect of fragmenting the relationship between concerned parties within the project organisation which in turn causes waste and adversarial relations such as distrust, between members (Elfving, Tommelein, & Ballard, 2005; Eriksson, 2010; E Johansen, Glimmerveen, & Vrijhoef, 2002). The outcome of these reactionary feelings tends to manifest in the form of risk contingencies such as additional financial costs and longer lead times (Elfving et al., 2005).
Toolanen (2008)advocates the use of lean practices as a substitute for traditional procurement methods whilst Eriksson (2010), who notes the need for higher levels of trust and cooperation between main contractors and subcontractors, suggesting that partnering is the answer to the problem. This opinion is also shared by Matthews et al (2000) and Agapiou et al (1998) who disagree with limiting this practice to the client/main-contractor relationship adding that other members of the supply chain are also affected and should be addressed, in particular the builder's merchants and other material suppliers.
Collaborative partnerships are a means of providing this harmonisation throughout the whole project organisation (J. L. Egan, Sir, 1998; Latham, 1994). By allowing partnering organisations to build on the relationship, trust is formed and parties are able to overcome their instinctive characteristics of mistrust (Humphreys, Matthews, & Kumaraswamy, 2003). According to Manley, Shaw and Manley (2007), partnering also promotes "shared goals, open communication, a mutually agreed upon strategy and a conflict management process that avoids costly and adversarial litigation"
Reasons for change in the procurement method include the need for greater involvement of downstream players in the design stage reducing the need for changes during later stages of the project. Also greater transparency promotes trust and co-operation, therefore reducing the need for risk aversion and further reduces costs (Elfving et al., 2005)

3.5 Behaviour

"*All organisations need to change and develop if they are to remain competitive and satisfy clients' ever increasing expectations*" (Price & Chahal, 2007). The construction industry traditionally has been resistant to change in the organisation structure, process followed and adopting technical innovations in the field. S. J. Egan (1998) reinforces this idea and suggests that due to low profits in the industry, little investment is done by the industry. (Littlemore,

2012) through her research in the UK construction industry concludes that resistance to change stems from the following problems;

- There is a disconnection between the different hierarchical disruption flow within the organisation.
- Representational behaviour from senior and middle management.
- Innovations do occur at the 'grassroots level' but are not effectively communicated throughout the organisation, which leads to them being localised.

In addition to these factors Johansen and Walter (2007) note that organisations need to be able to critically analyse themselves in order to implement any change. Egan (2002) further reports that change can be accelerated in the industry through collaboration and teamwork.

4. Lean as a tool for the construction industry

Egan (2002) says that "*Lean thinking presents a powerful and coherent synthesis of the most effective techniques for eliminating waste and delivering significant sustained improvements in the efficiency and quality*". Lean construction is a new concept that continues to evolve. However, the concept has developed the ideologies of Toyota manufacturing. A simple representation of the Toyota Production System was developed by Taiichi Ohno and Fujio Cho (J. K. Liker, 2004). The diagram below is the representation widely known as the 'TPS house'.

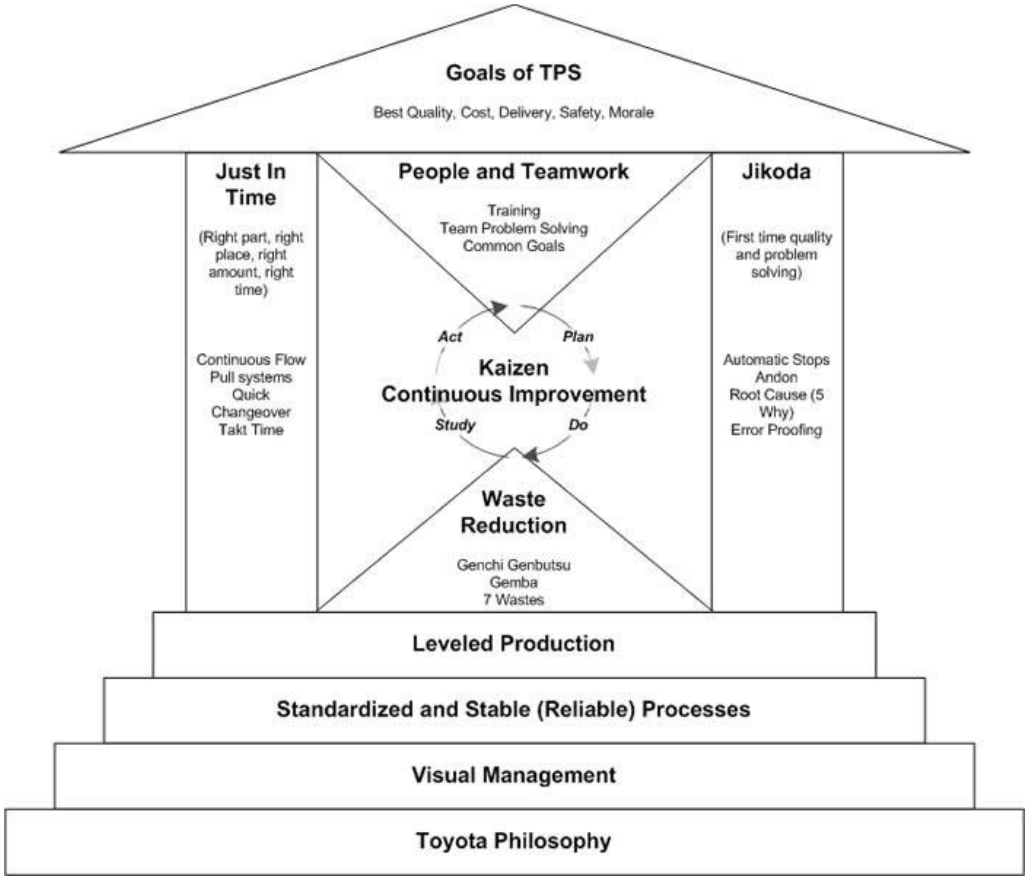


Figure___:- The 'Toyota production System House'(J. K. Liker, 2004)

The diagram looks like the representation of the house. The strength of the foundation of the diagram is demonstrated by the long term philosophy of Toyota. The other parts of the foundation supporting the house are visual management that relates to transparency in the process for reduction of uncertainty. Standardized and stable processes help in elimination of non-value adding wastes and establishing long term relationships.

Levelled production forms the basis for the pillars of the house providing stability, certainty and reducing waste in the process. The pillars of the house are formed by the concepts of just in time and Jidoka. Just in time is the tool used by Toyota to create flow in the process. It is the most important tool used to eliminate inventories and buffers, which are considered as waste by the engineers at Toyota. Jidoka is the concept that comes from the founder of the Toyota Group (Toyota, 2012). The idea looks at stopping the process whenever there is a defect. This tool requires checking and acting on the reasons for defect therefore 'building in' quality.

At the heart of the house lie the people, reduction of waste and Kaizen. Toyota looks at training people and developing them internally. By doing, so the goals of all team members remain aligned, thus maintaining the culture of the company. The idea of waste reduction has been drawn on to every aspect of the TPS house. Various types of waste have been identified and the people at Toyota make constant effort to eliminate them. This is done through Kaizen. Toyota constantly strives to improve their processes by employing the plan-do-check-act cycle. This has helped the company iron out any shortcomings in the ideology or processes they have employed. They therefore have the capability to constantly evolve and improve.

The roof of the house defines the goals which have been extracted out of the requirements of the consumer thus making the consumer an essential element of the system. (J. K. Liker, 2004)

There are clear problems associated with uncertainty in the planning and control, design, demand and procurement areas. Standardized and stable processes have applications in the department of supply chain management. This idea also influences creation of long-term relationships/collaborating within the industry as potential solutions for temporary networks, disjunction of design and build phases and disruption of flow due to traditional procurement processes. Levelled production as the facilitator of flow aids planning, design, demand areas of the industry.

The concept of just in time facilitates flow and since the establishment of flow exposes the hidden obstacles in the course, this ideology should be applied to all sections of the industry. The analysis of the problems points out those conflicts which are created due to interruption of flow in every aspect. The problems with defects as non-value adding waste has been pointed out in the areas of execution and design. This could be tackled by the introduction of concepts of Jidoka.

Elimination of waste has been discussed in every aspect thus strengthening the case for the use of Lean thinking. Development of people and Kaizen are alien concepts for the industry, which is based on projects. The projects are usually short-term and different projects often consist of varying teams. But the application of these concepts in the industry has promising long-term benefits for successful implementation of the other tools. Customer based

approaches have become extremely important in the current market situation for the construction industry. Thus, the 'roof' of the diagram would add value to the current practices in the industry. Finally, application of these concepts requires a change in philosophy from the current one. The analysis of the problems show certain obstacles encountered when bringing about large changes within the industry.

The principles of lean thinking are being adapted to suit the construction industry. Lean Construction Institute co-founded by Greg Howell and Glenn Ballard have developed the most established system using these principles (Forbes & Ahmed, 2011). This system provides an operation based approach for the delivery of projects using ideologies from lean thinking suggesting a combination of tools that help in in delivering projects more efficiently. The next section discusses the strategy to implement Lean thinking within an organisation based on some of the ideas developed by the Lean Construction institute.

5. Implementation

The process of implementing a system of lean philosophy into the construction company ethos has been divided into the five stages described below. The process is designed to be introduced during the participation in an actual construction project as the application of each aspect has been calculated to tally with a particular stage of the construction process.

As a means of bringing efficiency into the company through lean philosophy, it is the intension of this implementation strategy to overhaul the working culture of the organisation. This is a long term strategy and will come about through the adoption of the entire system.

5.1 Stage one

This process includes the facilitation of several lean tools which are intended to act as a demonstration of the capabilities of implementing the 'whole system' of lean philosophy via the introduction of individual tools. The focus is on waste reduction techniques and include, but are not limited to Last Planner, value streaming, 5 Whys and visual management. It should be understood that some of these tools will not display their full potential in isolation and will perform better as part of the a whole lean system approach (H. G. Ballard, 2000). It needs to be noted that this is a short term approach intended to reduce costs, and not truly lean (Seddon, 2005, p. 198).

Undergoing this stage will allow consensus to develop through demonstration of the capabilities of lean, (*Nemawashi)* (J. K. Liker, 2004, p. 241). It may also be missed completely in the event of full commitment by top management at this early stage. As demonstrated below, some aspects will be introduced anyway as a matter of course during implementation of future stages.

5.2 Stage two

The pilot scheme will create a model to analyse the limitations and expectancies of the full implementation of the lean system. It is in essence the prototype as well as the corner-stone of the process to construct the lean system, and will be formed within one single project.

Initial involvement at this stage will concern only those within the main contractor organisation. Lead teams should be formed here, drawing members from existing departments of the company who understand the current mentality and who genuinely advocate change within the system. Specialised tools are available for this purpose such as self-assessment and personality inventories.
Short term tools should be implemented, if not already introduced in the previous phase, focusing on the elimination of non value-adding movements and costs as well as optimising workflow (Green & May, 2005, p. 508). Tools such as JIT and value streaming are difficult to implement at this stage of the approach as they rely on the existence process, of which there is very little, though considerations should be given to the projected needs at the next stage.
At the same time it is also necessary to concentrate on the organisation itself. The internal process must be analysed. To do this the '5 whys' approach can be adopted to dig deep into the original culture of the organisation.
Top level management should be given training to help facilitate the implementation, understanding and management of the new organisational structure. It will also be necessary to provide training for the new lead teams that have been constructed, based on forward thinking towards the next stages of implementation.
Last Planner implementation will begin at this point, laying the track for the implementation of the new regime as well as the schedule of project works.

5.3 Stage three

At this point the lean system encroaches onto the supply chain to include sub-contracting parties, whilst still remaining within the boundary of the pilot scheme. The onus will be placed on collaboration between all members of the project organisation and will adopt a mixture of partnering and concurrent engineering. This will encourage the elimination of adversarial relationships whilst encouraging co-operation (Green & May, 2005).
A firm grounding for the introduction of concurrent engineering should also be established at this point as should the implementation of IT collaboration techniques like building information modelling (BIM), electronic data management (EDM) and electronic data interchange (EDI). These tools, although not necessarily lean, do eliminate movement and therefore reduce waste.
Attitude studies should be carried out in order to highlight any potential opposition, so it can be addressed at an early stage. At the same time internal process needs to be investigated to give a clear picture of how the interaction of individual players will take place.
Further training shall be provided for top level management, as well as for the lead teams, within the new companies to join the partnership. This should include delegates with decision making powers as Last Planner is to become a collaboration of all players in the partnership at this point.
A thorough review of the implementation progress throughout stage three is to be carried out in order to reflect on changes that need to be made to the remaining procedures.
Also at this stage standardisation procedures will be implemented and TQM systems put in place.

5.4 Stage four

This stage involves expanding the pilot scheme into the whole organisation. The procedure will take on the same form as the reviewed and improved pilot scheme though stage two may be adopted much quicker to bring the system in line with the pilot scheme.

The deployment of this stage may be delayed in order to further scrutinise the success of the pilot scheme or can be run concurrently to stage three. It is recommended that stage five is delayed until stage three has been implemented throughout the whole organisation and has been.

A thorough review of the implementation progress is to be carried out.

5.5 Stage five

Here the lean system expands further down the supply chain to include the main supply companies. The reviews from stages three and four (if applicable) will be analysed so as to allow for modifications to stage five. Attitude studies will be carried out to identify opposition and other obstacles. Also further investigation of the existing partnership will be made. This will help provide additional insight and monitoring of the current interaction between existing players.

As with preceding stages, top level management training will be facilitated for the new members of the partnership, and lead teams will be formed within them.

With the inclusion of material suppliers, Just-in-time mechanisms can now be implemented into the supply chain so as to reduce the potential from waste through poor flow, stockpiling and low quality.

Total quality management can be introduced at this stage

Standardisation is perfected

5.5 Further implementation

Once the lean system has been implemented throughout the immediate organisation the next stage will be to encourage the extension throughout the micro structure, i.e. the extended supply chain. Material suppliers have their own supply chains to manage and without compliance throughout the whole system true lean will never be attainable (J. K. Liker, 2004; Womack & Jones, 2003).It is also recommended that all the processes within the company are regularly reviewed to keep adapting the lean thinking to the company. This is an important step to achieve optimum results and implement the idea of *'kaizen'* (continuous improvement).

6. Description of tools required to implement the strategy.

The implementation of lean within a company had been divided into various stages and described above. Each stage warrants the use of specific tools and techniques in conjunction with the implementation of lean culture. To break free from the shackles of traditional thinking these tools act as vehicles for change within the company and thus become

important. This section provides a description of these tools with their potential benefits post their implementation.

6.1 Value streaming

This is a process that requires the study of processes and materials involved in the delivery of the final outputs. The idea behind this exercise is to differentiate between the non-value adding processes and the value adding ones. This is done by gathering data on cycle time, changeover time, working time, scrap rates and production batch sizes. By doing so non-value adding activities can be eliminated after due consultation with the team. Forbes and Ahmed (2011)suggest that start of the process currently involves move time, wait time and setup time, which are non-value adding activities. Move time is the time required to move a product or resource from activity to the other. Wait time stems out from the concept of mass production where products are delivered in large batches and wait to be processed. This could also be influenced by equipment downtime, shortages and unbalanced workloads. Setup time on construction sites is defined as the preparation time. Though this is an important phase in the process, it is believed that it can be reduced to a minimum. Other wastes that are taken into consideration are overproduction, defects and unused employee creativity (J. K. Liker, 2004). This ideology stems out of current payment processes of completing maximum between payment cycles. Defects are usually created when additional resources are employed on the construction activity to complete the work faster (Akinci et al., 2000). Through consultations and recommendations to the team, these can be eliminated.

Thus, the tool of value streaming has the potential of reducing uncertainties and non-value adding activities. Both these are done by forwarding recommendations to the team based on in-depth analysis of processes within the construction activity. Hence, this tool can be effectively employed by construction companies for problems occurring with planning and control. The scope of this activity can be broadened at the project level to define project objectives and success criteria at the start of the project. By doing so uncertainties generated by external factors affecting projects can be reduced. Thus, the problem of demand can also be tackled with the use of value streaming tool. However, this tool has to be clubbed with feasibility studies.

6.2 Last Planner.

Last planner is a system that looks at the increasing the flow in the project and has been developed by the Lean Construction Institute. At the heart of the system is the weekly plans developed by the 'last planners'. (Mossman, 2005) It consists of 3 phases, collaborative planning, look ahead planning and weekly work phases.(E. Johansen, 2012) The first phase of collaborative planning includes development of a three-month schedule by including the major stakeholders in the process. The second step of look-ahead planning aims to scrutinise the coming six weeks of work. This plan looks at the work that is ready. It would be futile to plan for the work whose essential pre-requisite is not complete. The final phase of the weekly work phases involves people from the lowest level in the hierarchy. The planning of this phase involves all subcontractors and their supervisors. They take the packages that have all the essential pre-requisites complete and make a commitment of delivery. This stage also

clearly defines the blockages and the constraints for the tasks to be undertaken. (E. Johansen & Porter, 2003). E. Johansen (2012) also suggests that the last planner consists of 2 other steps. The 4th phase is that of commitment planning where all the parties involved in the process agree to the complete the work. Clear answers are expected in this phase and uncertain answers like 'maybe' are not accepted. The final phase is improvement by learning. The companies adopting Last planner process are expected to adopt procedures to improve and adapt the system during and post the completion of the project.

Thus with clear benefits of improving the flow and reduction of uncertainties, Last planner is an efficient tool to resolve problems arising in the area of planning and control. The weekly, six weeks and three months plan aid the supply chain management. These plans clearly define achievable objects for the period making it an easy tool to decide the material required and take appropriate action.

6.3 Partnering

Strategic partnering is "the development of successful, long term, strategic relationships between customers and suppliers, based on achieving best practice and sustainable competitive advantage" (Lendrum, 2003)

In his report "Constructing the Team", Latham (1994) endorses teamwork, and collaborative partnerships in particular, claiming that they hold key to achieving greater client satisfaction. He states that in order to do so, project activity needs to be focused around the client.

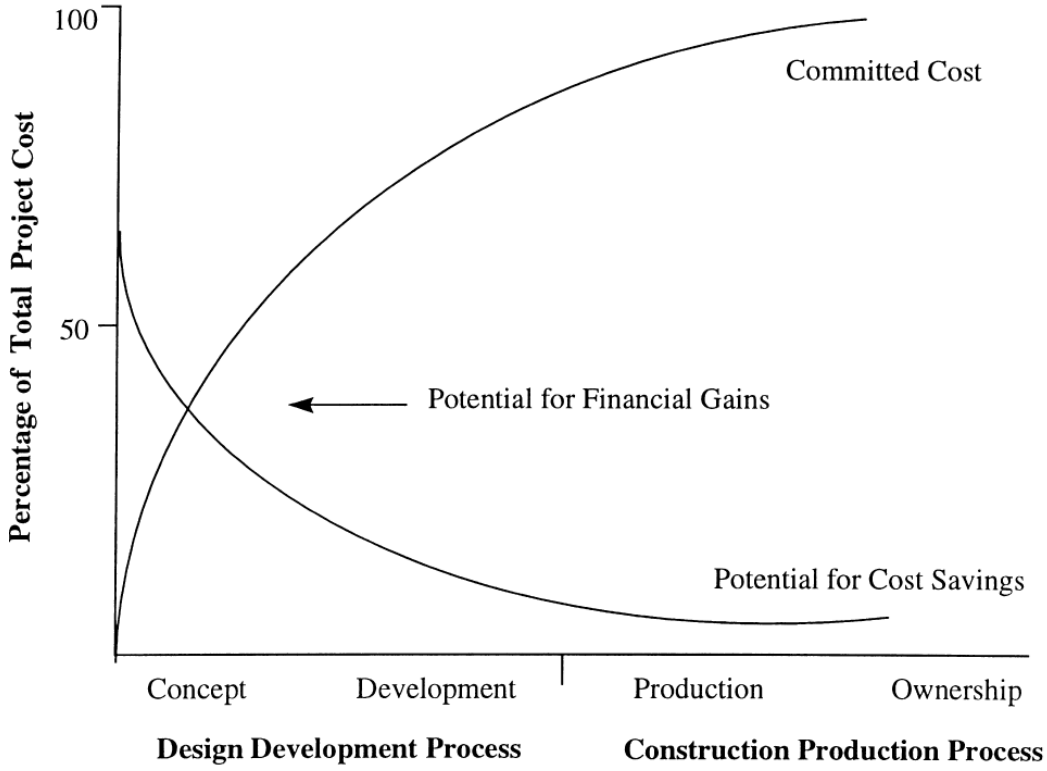
Egan (1998) follows this with claims that, by sharing risk, win-win scenarios could be instigated for partnering players, whilst at the same time raising the quality of construction and improving the project environment (Matthews et al., 2000). Other benefits on offer include a framework for reducing conflict (Chan, Chan, & Ho, 2003; Common et al., 2000), reduced costs and improved time savings (Crespin-Mazet & Portier, 2010; Vrijhoef & Koskela, 2000) as well as improvements in design process, communication and buildability (Matthews et al., 2000).

In order to facilitate the cooperation of the partnership smoothly and effectively, a high degree of ownership and commitment is required, especially from the client (Chan et al., 2003; Matthews et al., 2000). In addition, Crespin-Mazet & Portier (2010) include trust and the sharing of objectives as pre-requisites for the success of partnerships.

6.4 Concurrent engineering

Concurrent engineering facilitates multiple disciplines (both design and functional) into the design phase of the project and allows them to run in parallel rather than in sequence (Love, Gunasekaran, & Li, 1998). This approach encourages the early location of problems and allows for rework to be completed before it creates downstream issues (Love et al., 1998). Green and May (2005) advocate the adoption of this technique by involving subcontractors early on in the design stages. They further recommend combining design with the construction schedule to help improve collaborative working, problem solving (Winch, 2006) and customer focus (Eriksson, 2010).

Love et al. (1998) go on to state that while concurrent engineering has the potential to improve project efficiency, it is reliant on the participants' interaction at the appropriate level and take the holistic approach to design and build process.
From the perspective of this strategy, it is recommended that concurrent engineering techniques are incorporated alongside the general collaborative partnering model as a means of facilitating value from the early stages of the design phase.



The figure above illustrates the potential for financial gains through the incorporation of collaborative techniques in the early stages of the project.

6.5 Visual Management

Visual management is also known as 'control by sight' and is the considered as the 'Litmus' test for Lean thinking (Bicheno, 2004). This tool has been considered important for resolving the problems arising in the management and the execution areas of the construction industry. Adoption of this process creates transparency in schedules, standards, problem solving processes, quality etc. This tool is the foundation bed for lean principles like *Kaizen, Nemawashi,* team working, standardisation and problem solving to flourish. This tool lowers the level of flow (in conjunction with other tools) and exposes hidden obstacles in the process. Commitment charts, safety signs, project milestones, standardised task sheets, defects etc. are the parts of the information displayed at convenient locations on site. The information boards have to placed intelligently because construction typically consists of mobile workstations and scattered placement of resources, which could potentially reduce the transparency and flow of information (Forbes & Ahmed, 2011). Toyota uses *Andon* system to immediately recognise problems and correct them before the product moves to the next stage

(J. K. Liker, 2004). This helps in reducing defects at the source and surfacing the problems as they are noticed. By adopting *Andon* system waste of overproduction and defects is considerably reduced. Similar techniques and culture needs to be developed in the projects so that defects are immediately flagged. Kemmer et al. (2006) have shown that there was productivity increase of 100% by the use of visual management tool in Brazil.

6.6 Total quality management

The term 'Total Quality Management' has been defined as "*a system of management based on the principle that every member of staff must be committed to maintaining high standards of work in every aspect of a company's operations"(Oxford).* Some of the key concepts under this tool are quality for profit, right for the first time, cost of quality, benchmarking, involving everyone, rewards system, standards, quality accreditation etc (Bank, 2000). The foundations of total quality management and lean thinking lie of similar principles of basing the focus on the customer, building in quality right from the start and involving everyone (Nemawashi). Thus, this tool has been considered as a strategic tool to aid the management of the on-going processes during project. This tool also aid in building quality and reduction of waste in the supply chain if extended to partners in the supply chain (Wong, 1999). Key themes like customer value, organisational system and continuous improvement lie at the heart of the total quality management thinking (Bounds, 1994). Within the theme of customer value traditional topics like quality, measurements, positioning, stakeholders and designing get an external outlook with the end-user becoming the centre of thinking. Similarly internal parameters of employee involvement, technology, control become strategic indicators rather than mere facilitators for the project to be delivered and begin to define the theme of organisational system.

6.7 Just-in-time

Just in time is the tool that promotes the flow within the production using the pull system. It was developed by Toyota and is understood as the need to replenish the right inventory at the right time (Tommelein & Li, 1999). The application of this tool results n lower inventory, less work in process, shorter lead times, lesser floor space area required and lesser costs (Forbes & Ahmed, 2011). This has been found to be an effective tool to resolve problems arising due to flow in the areas of planning, management and the supply chain management. This tool has to be applied in conjunction with Heijunka (levelling workload) because the construction industry operates in a volatile market situation where the demand can fluctuate over the span of the project. Even after using Just-in-time in conjunction with Heijunka there is a risk that the resources may fall to a critical level at critical (Forbes & Ahmed, 2011). Thus, the tool also warrants close relationships with the supply chain and smooth flow of information between all aspects of the supply chain. The close relationships are developing through partnership and collaboration as described in the section ____. Pheng and Hui (1999) reinforce this idea and expand the scope of the stakeholders involved under Just-in-time to client/consultants, subcontractors and the workers on site. They have also shown significant improvement in the efficiency through the application of Just-in-time in the site layout planning in conjunction with other tools described.

6.8 Five-whys

The ‘five-whys’ is the simplest and easiest tool to implement within the tool-box. It is about asking 'why' 5 times once the problem has been identified. This is done to reach the 'root cause' of the problem rather than the source. This leads to an upstream in the process and deeper into the organisation thus providing long term solutions for the problems and potential prevention of reoccurrence (J. K. Liker, 2004). Forbes and Ahmed (2011) suggest the following steps in the process:

- Ask why a particular process deviates from expectations
- Ask why the answer is stated.
- Repeat the question until the root cause if found.

Identification of the root cause helps resolving problems arising in the industry and prevents reoccurrence of the same problem. This helps in eliminating wastes occurring in projects. This is an important tool that can be used in all the parts of project and the results would be evident in short term. Thus, this a tool proposed in the initial stages of implementation of Lean.

6.9 Standardisation

Henry Ford wrote back in 1926 *"Today's standardisation... is the necessary foundation on which tomorrow's improvements will be based" (J. K. Liker, 2004).* Standardisation is considered as the foundation for continuous improvement. J. K. Liker (2004) is of the view that you can standardise only what you know best, thus creating the right atmosphere for innovations and improvements. Gibb (2001) have found that standardisation and pre-assembly can help in streamlining the overall construction process, reducing waste and saving project team resources. This has found to be extremely beneficial in projects that have repeat client orders. In construction, each project is unique however in areas of health and safety, handling of materials, the learning curve is reduced for future projects. By the adoption of the standardisation processes, design decisions have to be taken early by mutual consent of all stakeholders. This tool also promotes the idea of collaborative partnership and concurrent engineering. Thus, standardisation of processes is an effective tool to resolve problems arising with design, management and installation.

6.10 Other tools

From the outset of the implementation strategy certain other lean tools are offered (stage one). These include Six Sigma, theory of constraints, cost containment and the use of supply chain software.

Individually these methods offer short term solutions and are meant as an appetiser for what is achievable through lean implementation through our recommendation of the whole system concept. Even collectively they will not offer a long term solution as they do not promote the mind-set change of management (Seddon, 2005). This is not to say however, that in the event of the full strategy being withdrawn, these tools should also be scrapped

7. Conclusion

It can be concluded that almost all problems within the construction industry lay within the fields of Planning, control, execution, design procurement and behaviour. In order to facilitate the elimination of potential failure, a new regime of organisation and process must be implemented. As a means of providing efficiency and eliminating failure within organisational processes, the lean philosophy is found to be a proven mechanism, and is endorsed within the construction sector by both the Egan (1998) and Latham (1994) reports. We have therefore been able to offer our own interpretation of lean implementation as the means to eliminate failure in future projects, modelled partly on the Toyota Production System, with the inclusion of Ballard's (2000) Last Planner method.

The mechanism should be implemented slowly and clearly, and with a top down approach. This will help overcome cultural resistance within the organisation. Implementation will also need to be adopted as a whole system approach in order to allow for further improvements to occur naturally, as a part of the system.

The strategy is dependent on top level commitment, without this support the implementation will remain at stage one and await either a change in commitment or a re-evaluation of strategy. A short term strategy has been included at the initial stages in order to sway this commitment in the right direction. It includes tools such as Six Sigma and supply chain software, and is explained in section **5.10**.

Upon completion of the final stage, and the arrival at the 'goal', it should be understood that this whole system process is still not complete. As with the TPS, continuous re-evaluation of processes is essential in keeping up to date with change, iron out any remaining details, and provide on-going training for the advancing workforce.

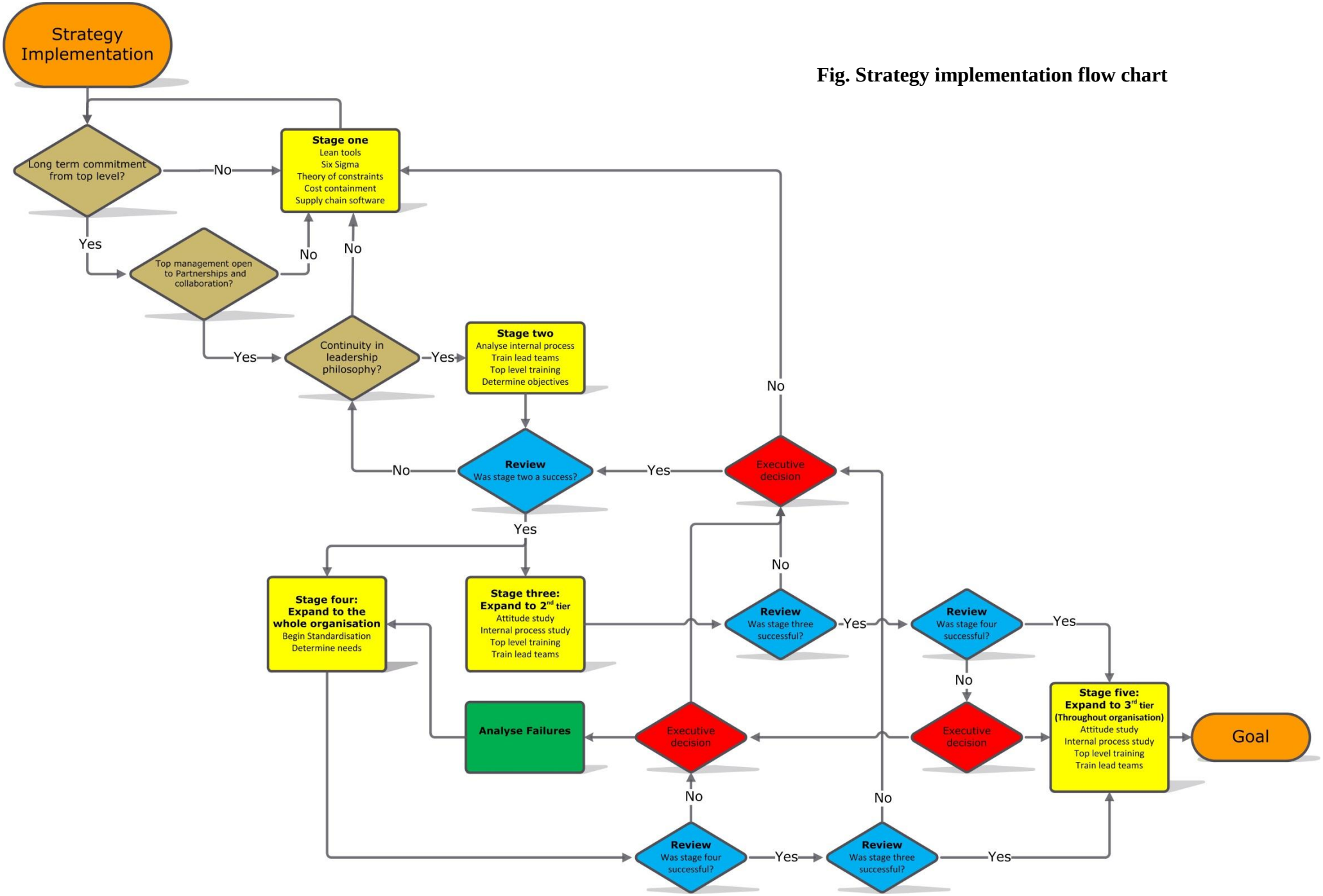


Fig. Strategy implementation flow chart

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