Lean Integrated Design and Production: a Contractor's Perspective

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Lean integrated design and production.

Date: 3rd May 2013

Introduction to Project Scenario

The scenario I have chosen for my paper concentrates on my experiences while employed as a senior estimator with Aidan Elliott Construction Ltd in 2009. Aidan Elliott Construction Ltd was a medium sized building contractor based in the Republic of Ireland. The company in question had an annual turnover of €15m, and was engaged in procuring construction contracts through competitive tendering. The contracts in question ranged in value between €200,000 and €12m. My responsibilities included pricing individual tenders, and compiling all the necessary documentation surrounding the procurement process for that company.

As a company, we were pricing work on a competitive basis based on very restrictive profit margins. The intention was to increase margins through better buying and production methods, once the projects became live contracts. However, through analysis we found that margins were being compromised due to excessive waste on site, not accounted for in submitted tender sums. We found that better buying was increasing margins post tender on certain packages, however these gains were being threatened by the level of waste tolerated on site. The waste percentages were identified by conducting reconciliations at final account stage on materials used against tendered quantities. Generally our tenders included an average of 3% in material quantities to cover unavoidable waste, such as cutting and nature of supply specific to certain materials. Our post final account analysis was delivering findings of actual waste in the region of 6%, twice the tendered allowance, due to excessive avoidable waste occurring on site.

REPORT FOR SENIOR MANAGEMENT

Brief rehearsal of the lean principles

The construction industry consumes vast amounts of materials every year, accounting for 50% of cost as an average on most construction projects. Who is responsible for materials management on construction projects? Cooke (2011) advises that with regard to materials “the responsibility for establishing policy lies with senior management.(Cooke p35 2011). Materials will form the main focus of attention in this report; however other forms of waste can not be ignored.
In order to inform management in a proactive manner on how to tackle current problems within our estimating department, it is prudent to research international best practice. Koskella (2008) advises on "The big idea of lean" advising that production occurs in a timeline, and if we specifically look at a material, there are good stages i.e. processing, and bad stages i.e. reworking, waiting and inspection. He further advises that we must eliminate the bad, otherwise labelled waste, before making the good stages even better. The fundamental problem can surround educating senior management that waste is accepted within the organisation, and in fact encouraged through bad practice. Koskella (2008) informs us that if waste is not in our vocabulary and mind-set, the chances are that high levels of waste are allowed to exist because we do not see it, termed accepted waste, or actively increase waste because we do not understand its causes, i.e. waste creation.

Koskella (2000) cites Ohno (1988) in his identification of seven main wastes, which are relevant to this report:

- Waste of overproduction
- Waste of correction
- Waste of material movement
- Waste of processing
- Waste of inventory
- Waste of waiting
- Waste of motion.

These waste headings are inherent in production, the initial five dealing with materials, while the final two deal with labour. Koskella (2000) feels that dealing with waste in production can be enhanced by flowcharting the process, and highlighting problem areas for attention, and adapting the following measures:

- Reduce the lead time
- Reduce variability
- Simplify
- Increase flexibility
- Increase transparency

There are international theories common to a number of industries with regard to the productive sciences. What modus operandi is adapted to achieve design and production in general. How to achieve this in shortest time and lowest cost. And the overall concept of achieving the optimum value for the customer. The conceptualisations of production can be broken down into T, transformation, F flow, and V value generation. The traditional view of production surrounds T as outlined below.
However, the flow view on production is more in keeping with the “big idea of lean” and supports the eradication of unnecessary waste in production, which is the key objective of this report.

Construction by its nature is unique in terms of production due to the one-of-a-kind nature of its products, temporary nature of sites, and the variance in material specification on every project. There are different views relating to these peculiarities, and how these peculiarities should be facilitated. I agree with the hypothesis that construction peculiarities contribute to waste and value loss, and it is necessary to reduce those peculiarities or to mitigate their impacts at the level of control and improvement. This theory will be further explored later on in this report when actively sourcing solutions to the current estimating problem.

When investigating international best practice with regard to lean principles of production, careful attention must be given to the 14 principles outlined by Liker (2004) in his publication: The Toyota Way

The innovations and principles of lean outlined by Liker (2004) in this publication are relevant to many facets of the construction industry from conceptual design through to project handover. This is despite the obvious differences between the construction and motor industries. The underlying themes explored within TPS are universal from an application point of view. The overall goal being the elimination of all waste that adds cost and no value. It advocates the empowerment of individuals with problem solving abilities. It places more emphasis on performance motivation rather than management (Liker 2004).

**Critical evaluation of the current process.**

**Major Concerns**

The excessive material waste percentage was causing grave concern for the board of directors for a number of key reasons:

- Expected profit margins not being realised on certain contracts.
- Poor management techniques on site resulting in high wastage percentages, not in line with good quality management
As the economy was in a state of contraction, there were concerns that the company would become uncompetitive in future if these waste percentages persisted.

- Excessive waste from an environmental viewpoint.

**Critical evaluation**

I have decided to conduct a critical evaluation of process as it existed prior to addressing the waste issue. by using the 14 principles outlined in TPS as a performance evaluation technique (Liker 2004).

**Principle 1** Long term philosophy.

The prevailing philosophy which existed in the company placed the responsibility of waste management for each project on the shoulders of individual project managers rather than adapting a company wide policy. This resulted in an inconsistent approach to waste management on each individual site. Hence the levels of waste occurring on each site varied greatly depending on the site management attached to that particular site.

**Principle 2** Create continuous process flow to bring problems to the surface

The knock on effect of deficiencies relating to principle 1, led to a lack of initiative in this area. Inefficient systems within the company were hampering the process flow. Problem areas were not being highlighted with due diligence, and this contributed to high waste percentages. For example inadequate storage of materials illustrated below where plasterboard was exposed to weather.
Principle 3 Use “pull” systems to avoid over production

The company was quite strong in this area, with materials ordered in line with the agreed programme, avoiding the temptation to bring materials to site early, avoiding restocking charges if change orders were introduced. An illustration of a typical programme is outlined below.

Principle 4 Level out the workload

There is a culture prevalent in the Irish construction industry where employee’s and plant are overburdened when trying to achieve unrealistic programmes, which in many cases makes the situation worse. This was the case on many of our sites.

Principle 5 Build a culture of stopping to fix problems to get quality right the first time.

This was inconsistent from site to site, and where site management was weak, the result was large snag lists at the end of the projects leading to waste, as materials had to be ordered out of sequence with the original project programme. In my opinion, excessive snag lists have a major influence on waste percentages on any given programme. There can be difficulties pursuing subcontractors to return to site to complete remedial works. In many cases the retention monies held on these subcontractors was not sufficient to cover the cost of addressing the outstanding remedials. The management on site should ensure that remedial works are completed prior to the departure of that particular subcontractor. For example, snags to lead work on a chimney not completed in time can lead to extensive damage internally later on, which will result in waste.
Principle 6 Standardised tasks are the foundations for continuous improvement and employee empowerment.

The underlying problem here within the company was the absence of an agreed site waste management plan, which resulted in waste not being dealt with in a strategic manner such as waste segregation, and reuse of materials. On some sites all waste was being disposed in the same skips.

Principle 7 Use visual control so no problems are hidden

Management were not spending enough time on site where a quick visual inspection would highlight many of the waste problems inherent on sites. The photograph below illustrates a tolerance for incorrect storage of materials which even to the untrained eye was unacceptable.
Principle 8 Use only reliable thoroughly tested technology that serves your people and processes

The company was quite strong on this principle, and were generally well experienced in choosing the correct technologies and plant as required.

Principle 9 Grow leaders, who thoroughly understand the work, live the philosophy and teach it to others.

The company employed very experienced project managers who were well versed in their daily tasks. Indeed most of these employees had been with the company for a substantial amount of time, and had strong reputations in their areas of expertise. The missing part of the equation was the company philosophy. If the philosophy could be reinforced, the company had leaders who would develop the ethos.

Principle 10 Develop exceptional people and teams who follow your company’s philosophy.

This principle is a development of principle 9 above, and would not be an obstacle once the company’s philosophy was amended.

Principle 11 Respect your extended network of partners and suppliers by challenging them and helping them to improve.

This principle is an important component of this report as the contractor in question depended on subcontractors and suppliers to carry out the work. The company built up relationships over years with the same subcontractors who were tried and tested, and could be relied upon to deliver quality work on programme, and on time. It could be argued that a main contractor’s reputation is only as good as his subcontractors.

Principle 12 Go and see for yourself to thoroughly understand the situation.

This was another area which required attention. There was sometimes reluctance on the part of senior management to spend sufficient time on site to fully appreciate the problems with regard to waste. They preferred to rely on feedback from project managers who unwittingly would present that feedback from a biased viewpoint. This resulted in decisions being taken without an informed knowledge of the real underlying problems.
Principle 13  Make decisions slowly by consensus, thoroughly considering all options, implement decisions rapidly.

Decisions were being made inconsistently, in many instances on flawed feedback from project managers. The reluctance on the part of management to make regular site visits led to poor decision choices, which again feeds into the need for a comprehensive revision of the company philosophy.

Principle 14  Become a learning organisation through relentless reflection and continuous improvement.

There was an appetite to adapt principle 14 once the deficiencies highlighted against the other principles were addressed. The idea of continuous improvement was desirable to senior management, along with an appetite for the implementation of necessary training to facilitate the development of a more efficient philosophy throughout the company.

Development of a target process based on consideration of alternative approaches

Strategy

The company directors were aware that waste existed within the company on many different levels as highlighted above. However a decision was made to concentrate efforts on material waste as a matter of urgency, and other areas of waste would be addressed in the future. It was decided that a waste management system would have to be implemented, tailored to meet the needs of our organisation. A number of proposals were offered by company directors for discussion, and the merits of each proposal were discussed. Possible strategies investigated as a solution were as follows:

1. When procuring work in the future, ensure that all materials were included in each subcontractors work package. This would transfer the risk relating to materials waste, and ensure that this was now the subcontractor’s responsibility.
2. Introduce contracts of agreement with site management where target waste percentages were set and signed up to by both parties. Bonus payments would only be paid if target percentages were achieved.
3. Design and implement a waste management system for sites, whereby procedures as part of a quality assurance plan would ensure that the site was managed in a manner conducive to better waste management.
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Once the three most favoured strategies were agreed, there then followed a forensic evaluation of each of the possible strategies.

**Consideration of alternative approaches**

The company directors considered each of the approaches by summarising the advantages and disadvantages relevant to each strategy

Option 1 – Advantages

The overall advantage of ensuring that each subcontractor’s package included plant, labour and materials in their subcontract sum, was that the risk of material waste became their responsibility. It basically shifted the risk from the main contractor to the subcontractor. It also would ensure that valuable site management time could be directed towards different tasks, possibly reducing the cost of site management. Another advantage of this approach was that less time would be allocated in head office with regards to material purchasing, invoice administration, and policing of this area in general. Subcontractors would now have to deal with this burden, and include the financial risks associated with this inclusion within their submitted rates.

Option 1 – Disadvantages.

At first glance this approach appeared to be the obvious method of dealing with the material wastage problem; however a number of disadvantages were identified. Firstly subcontractors would not only have to allow the cost of materials in their rates, but also material wastage percentages, hence it was inevitable that their rates would increase. The pool of subcontractors available to price the various subcontract packages would now drop significantly, as many of the traditional choices of subcontractor utilised by the company would now be no longer available. They would not be in a position to carry the added burden of materials cost. For example: blocklayers would traditionally provide a labour only price per block layed, and not actually supply the blocks and mortar which were supplied by the main contractor. These subcontractors would not have the financial capacity or credit terms to supply materials. The list of block laying subcontractors available to price this package in the future would decrease dramatically. Our company was tendering for work on a competitive basis, and required the most competitive rates possible from subcontractors to ensure work flow. This could negatively affect our competitiveness going forward. Our company attracted large discounts from suppliers of certain materials due to the large overall volume of business conducted with our suppliers. Smaller subcontractors may not be in a position to attract the same discounted rates, and this would be reflected in the overall cost of completing the work.

There were also concerns that the company would lose their control over the quality of materials being used. There would be a temptation on the part of subcontractors to take shortcuts with regard to specification. Subcontracts would prescribe the required specifications, however the enforcement of these specifications would require careful monitoring. This could neutralise the intended savings in the site management area. The control issue with regard to delivery on site and storage could also present problems, especially on restricted inner city sites where space may be at a premium.

The company weighed up both sides of the argument and felt that the practicalities of implementing a system of this nature was not feasible. It may eradicate the material wastage problem, however
have a negative effect on overall competitively of the company and jeopardise successful tendering in the future, especially in light of current economic trends.

Option 2 – Advantages.

The overall advantage of this option was the emphasis on personal responsibility. It involved the site management team buying in to target waste percentages. The philosophy inherent in this proposal was that project managers would treat materials on site with the same fastidious approach as if they were intended for their personal use. It was felt that project managers would try to exceed the target percentages signed up to, as they would benefit financially from this saving. This was seen as a win-win situation for both company and employee. Materials generally account for 50% of cost with regard to any construction project, hence if target waste percentages were bettered; it had the potential to substantially increase company profits. This option would also make the project manager a meaningful stakeholder in the profitability of the company. It would give him the opportunity to increase bonus payments through better management. This option would reduce the requirement for senior management in the company to closely supervise the performance of individual project managers, as the incentives in place would act as a replacement.

Option 2 – Disadvantages

The main concern surrounding option 2 was that Project Managers may become obsessed with waste targets at the expense of everything else on the project. Again, like in the last option, there may be a temptation to take shortcuts with material consumption. For example a 300mm thick concrete foundation may only be poured to 280mm for no other reason than bettering waste targets with the bonus being the incentive rather than the interests of the company. This could leave the company exposed legally. Also the reputation of the company could suffer if other aspects of the project such as quality and programme were to diminish as a result of this incentive scheme. There was also a concern that unwelcome competition may arise among project managers as a result of this scheme, which could corrode the team spirit among colleagues. Certain project managers may feel disadvantaged due to their particular project assignment, comparing their allocation with more favourable projects held by their colleagues. This could ultimately lead to experienced managers opting to leave the company. Senior management also felt that where targets were not achieved through no fault of the project manager, there may be a loss of confidence on that manager’s part affecting his performance going forward.

Option 3 – Advantages.

This option offered a long term solution to waste management within the company which would not only reduce waste but potentially change the mind-set of the company and create a new philosophy for the future. It was felt that if project managers had direction on a distinct company policy in this area, it would drive a uniform approach to how the company not only managed their waste, but also how they managed their projects in all areas. If a policy of better planning existed, and responsibility was properly allocated, this would help the company to tackle not only material waste, but also the other main forms of waste discussed earlier in this document. The success of this option would depend on education within the company and appetite for change among employees. The primary advantage of the successful implementation of a waste management system would be a more competitive company in the tendering arena. This system would ensure that target material waste
percentages were being achieved through better planning. Waste would be identified and managed properly. This system would undergo continuing evolution based on the experience gained from project to project. There would also be substantial benefits to the environment where a reuse and recycle approach was adapted. Also from a financial perspective, segregated waste such as skips for timber, steel, plasterboard, etc. attract tariffs which are considerably less than general waste skips. It was also felt that the visual impact of sites would benefit from a more organised approach to waste, where the company reputation would be enhanced.

Option 3 Disadvantages.

The cultural and educational aspects of this option raised concern among senior management. Many of the project managers were with the company for a number of years. Would it be possible to change their mind-set, and methods of management? Would an insistence that new management systems relating to waste cause disruption within the company? There were also concerns that the implementation of waste management plans on all sites would result in greater labour costs associated with segregation of waste. There was speculation that programmes may be lengthened due to increased management demands.

Decision based on consideration of 3 options.

There was unanimous agreement among company directors that option 3 was the most suitable strategy for the company looking to the future. They felt that the matter required a change in the philosophy of the company rather than short term strategies which may produce results on a temporary basis. They felt that the economic collapse of the Irish construction industry presented main contractors with the challenge of adapting to change or face extinction. Bruce Shaw (2010) published the following graph illustrating output.

Figure 1 Construction Output
Despite negativity surrounding the construction industry relating to output and employment, contractors were faced with the prospect of having to survive. Output in the Irish construction industry peaked at close to €39 billion or almost 25% of GNP in 2006, the ensuing adjustment has led to the value of output falling to €8.7 billion in 2009, or 7% of GNP. Our company was well aware of the implications arising from such a radical decline in output. Tendering in this environment was going to become even more challenging in the coming years. To ensure survival, the company would have to operate in an efficient lean manner, which would require radical shifts in the way the company managed waste. There would be little room for waste percentages in future tenders. This made the company focus on option 3. The disadvantages associated with this option were educational and cultural in nature. However an overhaul was necessary in any case with regard to economic constraints, so this presented the ideal time slot to address the undesirable culture of waste.

**Implementation plans**

Once the decision was made with regard to tackling the excessive waste amounts occurring with regards to material wastage during production, an implementation plan had to be introduced. The advantages and disadvantages were reviewed. A basic philosophy was generated with regards to material waste on site, which is illustrated in the following diagram:

<table>
<thead>
<tr>
<th></th>
<th><strong>Eliminate</strong></th>
<th>Avoid using waste in the first place.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td><strong>Reduce</strong></td>
<td>Minimise the amount of waste you do produce.</td>
</tr>
<tr>
<td>3</td>
<td><strong>Re-use</strong></td>
<td>Use items as many times as possible.</td>
</tr>
<tr>
<td>4</td>
<td><strong>Recycle</strong></td>
<td>Recycle what you can only after you have re-used it.</td>
</tr>
<tr>
<td>5</td>
<td><strong>Dispose</strong></td>
<td>Dispose of what’s left in a responsible way.</td>
</tr>
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</table>

This philosophy was then translated into a site management waste plan template to be used on all sites commencing from an agreed date. This plan would assess the types and amounts of waste each project would produce, and determine how that waste would be managed. The plan would be subject to continuous improvement monitoring which would act as a means of reducing waste on future projects. The steps required to generate a site waste management plan is illustrated on a step by step approach as highlighted below. It was agreed that this template would be used on every site prior to commencement. On completion of any given project, the site waste management plan should give an accurate record of how effectively materials on the site have been managed and how well the waste management targets have been met.
This stepped approach was presented in a manner that was easy to understand from an employee perspective, and was subject to continuous improvement.

Using the nine steps listed above, each site would now have to follow this procedure:

**Step 1 Plan and prepare**

This step was initiated prior to commencement on site. Discussion involved design changes with the design team which could make a significant contribution to preventing and reducing waste, eg

- Can we purchase materials with less packaging
- Would prefabricated construction be an option
- Can materials arising from demolition be reused

**Step 2 Allocate responsibility for the Site Waste Management Plan**

One person, eg the Project Manager should be responsible for implementation of the SWMP. That person should receive any necessary training.
Step 3 Identify your waste
Identify the types and quantities of waste that the project will generate:

- What types of skips are needed for the various project stages?
- Use segregation for different waste streams

Step 4 Identify how to manage your waste.
Store and dispose of all waste responsibly. Don’t mix different types of waste. Site setup should facilitate best practice.

Step 5 Identify where and how to dispose of your waste.
You must know where and how your waste will be disposed of.

- Waste contractors must dispose of waste safely and legally
- Only registered carriers can transport waste
- All sites receiving waste have an appropriate permit

Step 6 Organise your materials and waste
Savings are made from careful planning. Avoid over ordering.

Step 7 Communicate the plan and carry out training
Once a clear and concise plan has been developed, ensure that all employees know and understand the policy. There must be consistency throughout all sites. Subcontractors must also be aware of the plan.

Step 8 Measure your waste and update your SWMP
A recording and measurement system must be in place to monitor the plan.

Step 9 Review the success and learn lessons for the future.
This system must include the policy of continuous improvement.

The above steps form the basis for practicable implementation of the new policy. They address the challenges posed by the introduction of this new policy and facilitate the continuous measurement of the new system

Proposals for instituting continuous improvement along with performance measurement

The construction industry has been slow to adopt the concept of continuous improvement although it has been the norm in other industries for some time. This concept is very much an inherent part of the Toyota production system. It could be argued that a system of continuous improvement will not operate effectively in an organisation where structural problems exist. Continuous improvement requires organisation and structure. Koskella (2000) advises that the philosophy of continuous improvement includes a plan to improve your operations first by finding out what things are going wrong, that is identify the problems faced, and come up with ideas for solving these problems.
Liker (2004) gives details of the TPS continuous improvement system as simplified in the above diagram, and explains how data on improvement feeds back into design and operation. This process can be further explored in the following diagram:

The diagram reinforces the continuous nature of the process, thereby fostering an environment of continuous improvement. This includes monitoring techniques from tender through to final account on all new contracts, and an assessment of waste percentages to ascertain whether improvement was actually happening. This system can be applied effectively to the estimating problems explored in this report. The problem of material waste is identified and acknowledged by senior management within the company. A discussion then follows to investigate solutions to this problem. Once there is consensus on how to tackle the wastage problem, a plan of action is introduced. There must be a performance checking system to inform the company whether the plan of action is producing results as intended. The table below combines the theory above relating to the concept of continuous improvement and applies this theory to the scenario explored throughout this report.
The problems faced in this context include material waste percentages during construction on site exceeding the target percentages allowed in tender sums. The excess waste was eroding profits. The reason for the high waste percentages was due to poor site management in this area. There was no consistent company policy with regard to waste. There was no site waste management plan in place.

The company examined a number of options which could address this problem. The company researched the advantages and disadvantages of each option. It was decided to introduce a companywide policy with regard to waste in line with lean principles. The policy included the utilisation of site waste management plans for all sites.

This new system would undergo continuous performance measurement. This would be carried out by checking material quantities at tender stage against those actually used at final account stage. These material reconciliations would highlight whether positive change was being achieved.

This process would evolve based on results during the checking phase. If the experimental process is successful, larger scale changes will be introduced as the process evolves.

The process involves continuous improvement where the results are linked to planning for the next project, hence the process continues ad-infinitum.

Strategy for performance measurement.

The strategy for measuring performance requires close collaboration between the estimating department and site management teams on the ground. Bills of quantities are used extensively throughout UK and Ireland for tendering and procurement purposes. These documents include accurate records of quantities required to complete any given project. The quantities are assessed accurately at the pre commencement stage, and will act as checking tool once the project is completed. Once the project is completed a remeasurement of quantities will occur where the dockets from materials actually used will be compared against the original Bill of Quantities. Allowances will have to be made for variations during the project, and this can be built into the assessment. This procedure will be utilised on all projects, establishing what wastage was actually occurring, and how did this compare with percentages included in tender sums.
There will always be an amount of unavoidable material waste inherent in any project which has to be accounted for in tenders such as:

- Lapping Arrangements – mesh, dpc, etc
- Conversion Waste – cutting a 400 x 400mm access hatch from a sheet of plywood.
- Cutting Waste – timber generally.
- Application Waste – wet trades such as plastering – waste on floor
- Stockpile waste – loose materials dispersed on site eg clause 804, sand.
- Residue Waste – paints, mastic not fully used.
- Transit Waste – brittle materials, eg slate, tiles.

The above waste must be kept to a minimum, however the main focus of this report surrounds the elimination of avoidable waste which can causes serious financial problems if left un-checked. Examples of this category of waste are as follows:

- Mistakes in ordering.
- Theft – poor security.
- Quality control and work rejection – poor supervision.
- Misuse or substitution of materials.
- Depreciation due to bad storage.

The focus of this report was to highlight the problems experienced by our company in relation to the amount of unavoidable waste being tolerated on our sites, and to produce a plan of action in line with lean principles to tackle this problem. The concept of continuous improvement must be an integral part of a plan of this nature. A performance measurement technique is a fundamental inclusion to assess whether improvements are being achieved. The measurement techniques used in this report involve the study of actual versus budgeted material quantities. This technique will be time consuming from an administrative viewpoint, however necessary to reach informed judgement on the success of the policy. As tendering becomes more competitive due to the economic downturn in the Irish construction industry, meeting target material waste percentages will become a necessity for survival, rather than an aspiration.

**Innovation in the future.**

The company must accept that the application of lean principles are a necessity to survive in a more competitive Irish construction industry. The debate can not only focus on how to deal with the material waste problem as it exists, but to look to the future where investment in new technologies may provide the answer.

The introduction of Building Information Modelling (BIM) to the Irish construction industry is at a relatively early stage; however, the implementation of BIM on UK Government contracts by 2016 will most likely speed up the adoption of BIM in the Irish construction industry. Our company must
investigate if BIM is the tool to implement Lean Construction Principles in our organisation? Will BIM help or hinder work flow and improve communication between stakeholders? Does our company or indeed Ireland have the necessary skills at present to embrace the technology and start implementing Lean Construction Principles? Is BIM inevitable? The sooner our company can embrace the technology, the sooner we can reap the rewards?

Eliminating waste from the construction process needs to be addressed if true value is to be added to projects going forward. The value proposition to each stakeholder in the construction process must be understood if BIM and Lean are to work in tandem. Removing delays (waste) from the design and construction process will be central to their success.

Additionally, profitability needs to return to the industry, therefore, projects need to be delivered with a lean methodology in mind. Lean construction is defined by Cartlidge (2002) and cited by (Cooke and Williams, 2009, pp 105) as ‘the elimination of waste from the production cycle.’ Our company will have to embrace these new technologies going forward. The Irish Construction Industry is experiencing unprecedented times in terms of economic and technological change. Unfortunately, much of this change surrounds the collapse in economic activity, rising unemployment and basically trying to survive in an ever more challenging environment. When presented with the potential benefits of Building Information Modelling (BIM), many stakeholders in our industry, including our company acknowledge the importance of its potential, however we are more inclined to adopt a “wait and see” approach before becoming fully engaged with the process. BIM is a different way of thinking about construction that requires a move away from traditional workflow, with all parties including: architects, surveyors, engineers and contractors sharing and effectively working on a common information pool. The ultimate goal of BIM implementation is to facilitate Integrated project delivery (IPD).

IPD is a collaborative alliance of professionals, systems, business structures and practices into a process that harnesses the talents and insights of all participants, to optimise project results, increase value to the client, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction. IPD may only be an aspirational concept in Ireland at present; however the successful development of BIM to level 3 and above has the potential to make this aspiration a reality.

Within the context of this report, BIM and ultimately IPD will be the solutions with regard to material wastage into the future. If these technologies are ignored the company will fail to evolve into an organisation equipped to meet future requirements.

**Conclusion**

This report was compiled in order to investigate how the application of lean principles could be applied to a problem scenario within our company, and if implemented, what benefits would be generated for the organisation.

The scenario addressed, investigated the problem area of excessive wastage of materials on the company’s construction sites. The wastage percentages included in tenders were being exceeded by
the level of wastage actually happening on the ground. The company was engaged in competitive tendering and this problem area was threatening the future of the company.

The existing system was evaluated by using the 14 principles of TPS as an assessment of where the company stood prior to commencing a new lean process.

This report explained the theoretical benefits of lean, and using these theories, formulated different possible options for addressing the problem scenario. The advantages and disadvantages for each option were discussed. The preferred option was chosen which included the creation of a new company policy with regards to material waste, and an implementation plan was developed.

Once the new plan was implemented, a measurement process was developed adopting the principles of continuous improvement as guidance. This assessment of continuous improvement would feed into the planning stage of future projects so the system would be continually evolving.

The report also referred to new technologies surrounding the principles of lean as tools for the future, where through investment in technologies and training the company would increase competitiveness going forward.
References


