INTERVENTIONS IN EFFECTING CHANGE TOWARDS LEAN FOR AUSTRALIAN BUILDING CONTRACTORS: DEFECT MANAGEMENT AS A CASE OF REFERENCE

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ABSTRACT

Australian building contractors have been hesitant in embracing lean construction principles to date. The perceived gap between current practice and lean thinking, lack of simplified, user friendly tools to gain buy-in at site level have contributed as barriers. Others who have attempted some up-take have been discouraged due to lack of supporting cultural change to sustain the implementation of initiatives. The research conducted aims to reduce this gap through interventions to develop and refine simplified tools to effect cultural change towards defect avoidance. The purpose of this paper is to report the findings of two years of action research in characterising current rework perceptions and progress made through defect incident records.

An action research methodology that combined surveys and other empirical investigation for data collection and a cyclic process for interventions for change facilitation was adopted. Research was conducted on seven building construction sites in Sydney, Australia.

The results confirm the gap between current practice and lean philosophies, greater risk, hesitance and buy-in difficulties at site level in implementing lean thinking. The broader framework developed for defect management and Defect Incident Record was implemented successfully on the pilot projects. It provided a significant step towards change in belief in defect free thinking.

There are limitations in generalising the outcomes of this research as quantitative comparison of outcomes as a cause of interventions between construction projects are prohibitively difficult given the variety of variables observed. However, the qualitative comparisons provide valuable insights to further develop tools that may be used as a step towards the implementation of lean principles in construction.

KEY WORDS

Defect Incident Record (DIR), Defect Management Framework, Lean Construction, Defect avoidance, Construction rework, Culture change

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INTRODUCTION

Quality issues plaguing the Australian construction industry are well documented (Perera 2009). These issues compare very similarly to those reported in other countries and regions. Investigations to date have focused on characterising and quantifying these quality issues. Some have extended these investigations to include possible solutions and management frameworks. While it is acknowledged some isolated successes from research and industry initiated changes such as toolbox talks, increased use of IT and automated defect recording devices, the inefficiencies are still at an unacceptably higher level.

How can lean principles provide a solution to this challenge? Salem and Zimmer (2005) in their review conclude that customer focus, culture, workplace standardization, waste elimination and continuous improvement as the five major lean principles that are applicable in the construction industry. Erikson (2010) confirm that core elements of lean construction include waste reduction (also emphasised by Bollard and Howell 2003), process focus, end customer focus, continuous improvement, cooperative relationships and a systems perspective. Hence the lean perspective of waste elimination offers a fitting solution to address the defect issues discussed earlier.

Australian building contractors have been hesitant in embracing lean construction principles to date. The perceived gap between current practice and lean thinking, lack of simplified, user friendly tools to gain buy-in at site level have contributed as barriers. Others who have attempted some up-take have been discouraged due to the lack of supporting cultural change to sustain the implementation of initiatives.

This discussion focuses on this perceived gap between what lean offers as a solution to the construction issues identified using defect minimisation as a case of reference.

AUSTRALIAN CONSTRUCTION CHARACTERISTICS

SIGNIFICANCE AND PERFORMANCE

Construction has changed from being the most important source of urban manual employment in the 19th century (Butlin 1962) to be overtaken by other industries such as manufacturing, mining and property and business services. However, construction still remains one of the key industries influential in shaping the economic, social and political landscapes in Australia. Frenkel and Coolican (1981) reported that from a political standpoint, construction is particularly important for its association of home ownership with egalitarianism in Australia and the emphasis placed on the preservation of the environment.

The characteristics and issues affecting construction have been discussed for a long time (e.g. Bishop 1975, Ganesan 1984). To name a few, since early 1990s, construction has been lagging behind other industries both in productivity and productivity growth (Productivity Commission 2004), construction yields a low profit margin (4.6% in 2000/01) compared to 6.3% for manufacturing, 19.6% for mining and a total industry average of 9.3%, unacceptable levels of fatalities, injuries and related claims, etc.

The issues in construction quality compound the problems within this tight market. Defects and rework take up the best part of construction quality discussion in the literature. Focus on quality in the Australian construction industry intensified during the mid 1990s when the consultants and contractors were required to have the "quality stamp of approval", to gain government contracts. However, becoming certified to a recognised standard became more a marketing issue than a means to improving quality.

Hence quality issues remain largely overlooked. The Construction Industry Development Agency in Australia (CIDA, 1995) estimated the direct cost of rework in construction to be greater than 10 per cent of the project cost. In a more recent study Thomas et al. (2002) quantified the cost of defects analyzing over 3500 defects from four Australian building construction projects to be in the range of 3.4% to 6.2% of construction expenditure. Love (2002) in an exploratory study suggested that the indirect cost of rework could have a cost multiplier effect of three to six times the costs of actual rectification and therefore should not be ignored.

In addition to the high volume of defects, two further issues with the current defect identification and rework management practices in Australian construction compound the cost of rework (Marosszeky et al 2005):

- **Exponential cost of rework with time** - each trade builds on the output of the previous trade. Hence if defective work is not recognised at source rework cost increases exponentially with time; and
- **Long rework loop** - construction at present is characterised by long rework cycles that even if defects are identified early, completion of rework takes a lot longer.

LEAN AWARENESS

While lean adaptation in construction has gained momentum in other regions, it is observed that Australian building construction in particular has been skeptical in embracing lean ideas so far. The reasons relate to both the problem and the perceived solution. On one hand, the personnel at site level are attuned to accepting the current levels of defects and rework costs as normal and typical of the industry thus seldom see reason to change. On the other hand lean implementation as a solution to the construction issues, besides offering a framework and concepts for cultural change at management level, offers little in terms of tools and processes at site level that can be implemented easily with readily visible improvements in the area of defect management similar to the tools offered in the area of reducing variability and improving reliability (i.e. Last Planner, PPC, etc.). This is reflected in the observation that to date not one of the biggest building construction companies in Australia have adopted or embraced lean in their processes or culture or even mention 'lean' on their web sites. This has been acknowledged by four of the top 15 construction companies who were part of the sponsoring group for this research.

This paper discusses the lessons learnt from the interventions of a defect management framework on seven building construction projects in Sydney, New South Wales, Australia over the last six years. It investigates the possibility of using this simplified tool successfully implemented on two construction sites as a first step towards lean implementation by the construction industry.

METHODOLOGY

ACTION RESEARCH

Construction is a complex system. It is evident from the above discussion that most performance measures and behaviours are inter-related. Simplification of complex systems as a research methodology has been popular in construction related investigations. Such simplification, and at times over simplification, while is beneficial particularly to understand complex matters in detail, cannot be used effectively to derive practical tools for improvement as the outcomes are often suboptimal due to the simplified hypothetical pure form adopted. In fact many investigations to date have looked at the construction issues either from a production, relationship or culture point of view, but rarely have investigations considered them all together. Hence a research aiming to introduce industry accepted practical tools need to investigate the system in its natural setup in its entirety and introduce changes accordingly. This aim is approached through the use of an applied action research using a bottom-up approach.

In fact, participatory action research investigating the complete construction set up within its actual work environment has been identified as a gap that needs urgent attention (Azhar et al 2010). Azhar et al (2010) argues that, what is clearly needed in construction is a research approach that combines the objectives of both applied and basic research by contributing toward solution of practical problems and creation of new theoretical knowledge at the same time and proposes action research as the approach that fulfils these criteria. Hales and Chakravorty (2006) highlighted two major strengths of Action research as providing a rich explanation of "how" and "why" phenomena (problem under investigation) occur and studying the research problems in the natural setting which would be expensive, difficult, and/or impossible to replicate in a laboratory experiment.

Hence, this study follows a cyclic process of applied research on seven building construction sites in Sydney, Australia using the five step cycle as shown in figure 1 adapted from Baskerville (1999).

Figure 1: Action research cycle (adapted from Baskerville 1999)

It would be pretentious to claim that this research progressed systematically as reported in this paper. As is the case with many participatory investigations, the research questions were refined and processes modified during the course of this research at various stages and the evolution of ideas followed a cyclic process of planning, implementing, learning and changing.

It is noted that while this paper focuses on the interventions in waste elimination and continuous improvement approaches in lean, it is a part of a broader research that also included other construction characteristics such as customer focus and project culture to make this investigation a holistic process and some of which have been presented in earlier lean forums.

DIAGNOSIS

PROBLEM DOMAIN

The focus of this research is to develop a mechanism to avoid defects, particularly construction and subcontractor related defects, being passed on to the following trade to build on defective work. To this end, the handover of trade work from one subcontractor to the next is seen as the source point for defect avoidance.

Hence, it is defined that from a project perspective, an error becomes a defect if it is undetected at handover and therefore the following trade builds on such defective work. It may be argued that an error during the trade construction process can and should also be minimised or avoided. While this is true and certainly from a trade and productivity point of view it is in the best interest of everyone to do so, from a contractual point of view, the enforceability of such errors has very limited value.

INDUSTRY RESPONSE

When the research started six years ago, defect management processes within the six builders involved in the research were confined to Non-conformance records (NCR) and final inspection defect lists. Some construction sites implemented ad-hoc lists to manage day to day lists of incomplete work and rework. However, all of these were aimed at the contractual obligations rather than an improvement measure.

During the course of the research two head contractors rolled out IT based automated defect management systems. These involved recording of defects on personal digital assistants called ‘palm pilots’ and downloading them to a central defect database for analysis and rework management. Dong et al (2006) reported a similar system which has the added benefit of access from a remote site such as the head contractor main office.

ACTION PLANNING

PROPOSED DEFECT MANAGEMENT FRAMEWORK

An improved framework needs to address a combination of the key defect characteristics of encouraging defect avoidance, identifying defects early through an efficient defect management system and quick rework loop. The proposed Defect Incident Record (DIR) process is aimed to meet this requirement (see figure 2).

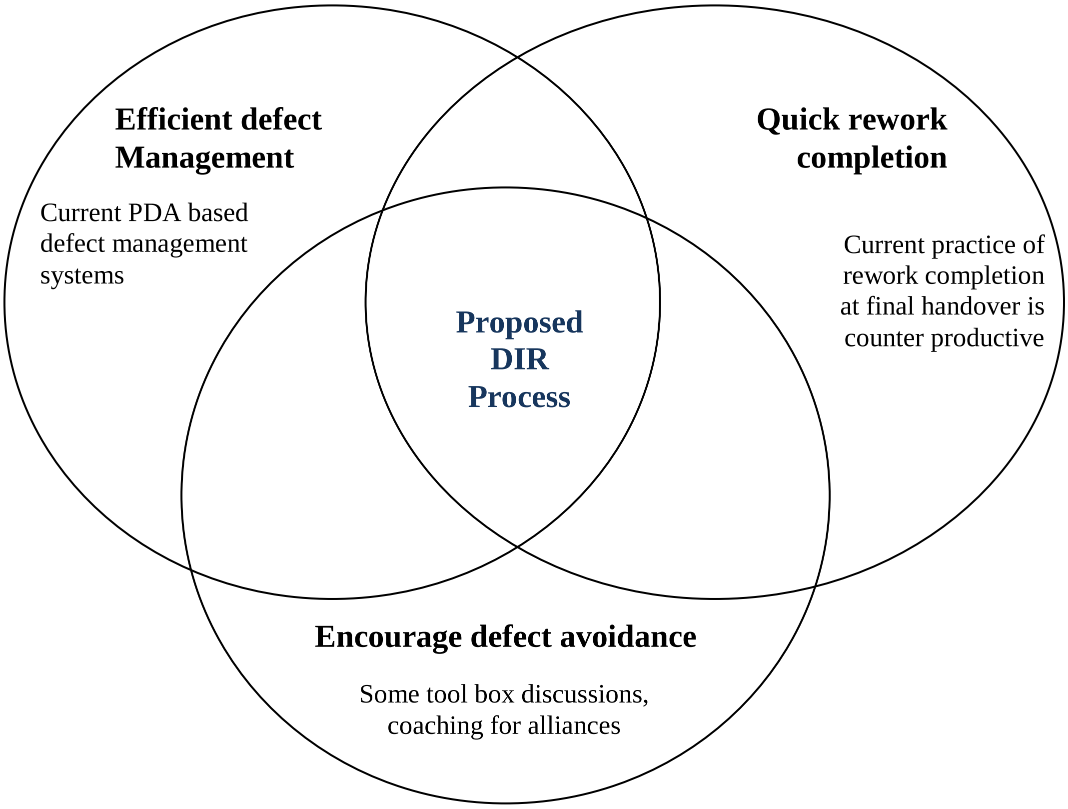

Figure 2: The proposed defect management framework and the relevance of DIR and current practice in addressing the three components

DEFECT INCIDENT RECORD (DIR)

The DIR process first developed as a simplified table used on the first two sites to regulate the exchange of defect and rework information between the researcher and the sites (Marosszeky et al 2005). The idea was to create a simple record on site to capture the occurrence of quality errors when they occur, and to communicate these to the researcher for later follow up in the analysis of root causes and timeline of rework. Initially these provided little value as a tool for root cause analysis; however it was beginning to see much better value as a simplified tool for defect and rework management on site. Hence, the tool was improved with the introduction of the following characteristics to meet the above factors of the defect management framework to make it a complete yet simple process to implement. See figure 3.

ACTION TAKING - IMPLEMENTATION

Each head contractor organisation that was part of the sponsoring consortium of industry partners was committed to providing a building project to implement the research actions. However, the research team had to obtain buy-in at site level to implement any new tools or processes. Therefore the site personnel had to be convinced of the added value of the new tools and processes before these could be implemented on site. This was a difficult task particularly considering that the research itself was about developing tools and processes during the course of investigations and interventions.

Defect avoidance/ minimization measures	• SC to minimize appearing on the sheets • Continuously drive down the number of open defects at a given time (target 2 sheets) • Reward (i.e. Issue recommendation/ reference letters) based on rework performance from the DIR
Efficient defect identification measures	• Continuously drive down the average time between sign-off date and defect identified date for each defect
Efficient defect rectification measures	• Continuously drive down the average time between rework completed date and defect identified date

Figure 3: Indicators of the DIR process that address the three types of measures as identified from the defect management framework

There were six head contractors among sixteen industry partners. As mentioned earlier, the DIR was first developed and used as a communication tool between the researcher and the site personnel on two sites. Two other sites introduced PDA based defect recording systems half way through the research and DIR was seen as a duplication of the process. The DIR process was implemented on two of the three remaining sites with one site having advanced too far towards completion to compare the benefits of the implementation.

EVALUATING - RESULTS

Statistical comparison of defects data between two projects or even two stages of the same project for that matter does not render a constructive analysis as the comparison of like-for-like is near impossible under those circumstances. Besides, the purpose of this research is not to validate the genralisability of the proposed processes through quantitative analysis, rather an exploratory study of the benefits to be derived from a simplified yet holistic approach to effective defect management through the proposed DIR process.

To this end, the following comparison provides valuable insights to the benefits of the proposed DIR process and how it differs from the PDA based defect recording systems.

Table 1: Comparison of defect results from two sites, one using the DIR process the other using a PDA based system

Description	Site A – using DIR process	Site B – using PDA based defect recording system
Site – project value	$5M	$38M
Site – Average no of workers	6HC, 30SC	12HC, 220SC[1]
Quality/ defect coordination role	Full time quality coordinator (QC)	Part of all site engineers' (SE) role
	D	D
	E	E
No of defect entries in a comparable month	12	286[2]
No of rework completed in the same month	10	42
Average time to identifying defects	1 week	Not known
Average time to rectifying defects	2 weeks	1.9 weeks to notify relevant SC[3]
Evidence of a reduction of the number of defects	Yes	No
Evidence of a reduction of rework times	No	No

[1] HC – Head contractor personnel, SC – subcontractor personnel

[2] Number of defects identified in a month were not readily available from the produced reports. However, a calculated figure was established by comparing two consecutive reports

[3] Average times to rectify defects could not be calculated from available data. However, the time to notify the trade from the sign off date is about 2 weeks.

CONCLUSION – SPECIFY LEARNING

While automated defect management systems offer value as an analytical tool to sort defects, etc., to date they have offered little value in reducing defect volumes and rework times. During the two years of observation of PDA based system, it was evident that this system did little to drive defects down, avoid recurrence or manage rework efficiently and quickly. Rather, the automated system required additional resources to manage the database, there were duplication of defects recorded by many site personnel, there were so many details required to be entered for each defect including estimated direct and indirect costs, etc., and one site ended up accumulating defect records to be completed at the end of the job before handover of each level where at one stage over 2800 open defect records were identified.

This substantiates that the industry need is not a mere tool. Rather, a process introduced with the correct objectives and a cultural change together with a renewed focus on internal relationships between organisations, particularly the customer supplier relationship between preceding and following trades.

The following key characteristics of the DIR process have been acknowledged by the sites that implemented it:

- **Key objectives of reducing rework costs** – by continuously driving identification and rectification times down;
- **Key objective of eliminating defects –** by driving down the number of open defects at a given time compared to PDA based systems focusing on sorting and managing rework (at one six month period Site B had over 2500 defects recorded in the system often duplicating some defects)
- **Uses fewer resources** – as the process is simple and therefore the defect management process itself is efficient (reducing non-value adding activities);
- **Management focus** – is maintained by tying the results to a reward mechanism for the subcontractors and seeks both head contractor and following trade input;

Green and May (2005), report that lean construction implementation efforts can be divided into three different stages, with increasing degree of sophistication. Stage 1 focuses on waste elimination from a technical and operational perspective. The responsibilities and focus are tied to managers rather than individual workers. The DIR process clearly is indicative of this stage 1 implementation process with focus on management intervention and waste elimination.

Hence it can be concluded that the DIR process offers a significant first step towards the introduction of lean principles to the Australian Building Construction industry.

FURTHER RESEARCH

As discussed earlier, this research was limited to developing and refining the DIR over a number of cycles. It is possible to now implement the refined tool to quantitatively assess its benefits possibly across a wider sample of construction projects moving into the different types of construction namely, residential, non-residential and engineering construction from an Australian point of view. It has been difficult to objectively quantify the benefits of DIR in terms of quality outcomes with other sites that didn't implement any specific defect management process as well as those two sites that used PDA based defect recording procedures due to the range of variables.

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