

A SURVEY OF THE TAKE-UP OF LEAN CONCEPTS AMONG UK CONSTRUCTION COMPANIES

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ABSTRACT

There are a number of initiatives designed to encourage the take-up of lean principles in construction. The aim of this research was to test the transfer of lean principles to construction by investigating their penetration into large construction companies in the UK. A conceptual framework with key indicators was developed and a survey carried out among a sample of general contractors.

The first objective was to explore whether there was any consensus on what constituted lean construction. Then the indicators that had been selected were tested for validity. The third objective was to explore whether the indicators were indeed present in the study organisations, and if so, whether lean principles were restricted to board level, or had actually filtered down into the site production process. Finally, the respondents, were questioned about the likelihood of lean production techniques being adopted in the construction process.

The survey revealed only a limited knowledge of lean construction techniques at both boardroom and site levels. There has been some adoption of lean techniques, but these exist side-by-side with traditional approaches. There was a great variation in perceptions: only a minority recognised the importance of the issues of design and planning. Many respondents professed to have embraced lean culture while further questioning suggested otherwise. Further research should investigate the reasons for this, and ultimately address the fundamental question of the transferability of lean principles to construction.

KEY WORDS

Lean production, take-up, transferability, survey.

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INTRODUCTION

Lean principles date back at least as far as the early 1900's, when Henry Ford revolutionised car production (Smook et al., 1996). In the early 1950's Ford's principles received a further impetus: Taiichi Ohno, an engineer at Toyota, realised that waste in mass production could be dramatically reduced, and made Toyota one of the world's most efficient companies (Womack and Jones 1996).

The seminal work on the application of lean principles to construction was produced in Finland in 1992, and is commonly known as Report No. 72 (Koskela, 1992). Its publication initiated the formation of the International Group for Lean Construction (IGLC), in 1993 (Chua et al., 1999) followed by other initiatives, including the Lean Construction Institute (LCI), the Lean Enterprise Institute (LEI) and the Agile Construction Initiative (ACI).

The general aim of these organisations is to promote lean principles in construction. Some (e.g., Green, 1999; Barlow, 1996) have questioned the transferability of lean principles from manufacturing to construction while others (Howell and Ballard 1999, Womack and Jones 1996) are convinced. The aim of the research reported in this paper was to test the current level of transfer of lean principles to construction by investigating their penetration into large construction companies in the UK. A conceptual framework, drawn from the literature and illustrating a number of key indicators or fundamental requirements for the implementation of lean principles, was used in a survey of large general contractors in the UK. The first objective was to test the level of understanding of lean construction concepts. Next, the study organisations were tested for the presence of the indicators of implementation. The third objective was to explore whether lean principles, where they existed were 'contained' at board level, or had filtered down into the site production process. Finally, the respondents, were questioned as to their attitudes towards the likelihood of the construction process being transformed into a production process.

FUNDAMENTAL ATTRIBUTES OF A LEAN APPROACH

From a review of the literature published to date it is possible to derive a set of fundamental attributes that are associated with a 'lean' approach.

The first fundamental is a procurement system with significant early emphasis on concurrent design and construction. The most effective was found to be design and build, though other forms, such as construction management and management contracting could also facilitate the implementation of lean techniques. The traditional approach, where the concept design is produced by the architect, passed to specialists for their input invariably initiates all kinds of rework. The design is then passed to the contractor, for pricing or for production (Ballard and Koskela 1998). Melhado (1998) suggests a new approach to design, that accommodates team work and adopts the principles of concurrent engineering, allowing all parties to develop the design simultaneously with early release of work packages. The use of concurrent engineering principles also permits the release of smaller design packages, which allows earlier involvement in production (Koskela et al 1997, Alarcon and Mardones 1998, Ballard and Koskela 1998 and Fabrico et al 1999). Koskela et al (1997) have identified a further adaptation to the design process, which

involves managing design as a production process, with the resources being made available for accelerated design development. The benefits of this are the reduction of rework created by the lack of integration between parties (Alarcon and Mardones 1998).

Construction planning has, for many years, been based upon the Critical Path Analysis Method (CPM). Recent research has indicated that CPM methods are incompatible with a lean approach, in that 'slack' is deliberately accommodated in the project plan (Ghio et al 1997, Akinci et al 1998, Tommelein et al 1998, Chua et al 1999 and Alarcon and Ashley 1999). Traditional project tools are no longer effective on large, uncertain and complex projects and a set of tools more consistent with project demands must be developed (Howell and Ballard 1996). The 'last planner initiative', developed by Glen Ballard of the University of California at Berkeley, is increasingly popular in the American construction industry and elsewhere. In addition to providing more certainty to the assignments that are released for production, the use of last planner has proven to achieve a greater degree of accuracy on the Percentage of Plan Complete Schedule (Junior et al 1998, Conte 1998, Choo et al 1998) particularly when accompanied by another technique, 'lookahead planning' (Ballard et al 1996, Ballard, 1997, Formoso et al 1998, Choo et al 1998, Chua et al 1999). On their own, however the techniques are insufficient: planning is a two-part process made up of planning and control, and 'last planner' in particular relates mainly to the latter (Formoso 1998, Howell and Ballard 1996). Ghio (1997) describes a technique called All Activities Critical Planning (ACP) and suggests that a change in the methods that are used to procure construction projects is required to successfully implement such a system. ACP is based on the premise that all activities within the project programme, will be carried out as scheduled and without delay. Ghio et al (1997), claim this can be achieved by closely matching crew levels with that of workable assignments. The use of advanced technology will quickly identify any potential deficiencies in either crew levels or assignments, which can then be acted upon before variances to the programme occur (Melles and Welling 1999, Faniran et al 1997). Faniran et al. (1997) describe the current state of the planning process as satisficing, and that this needs to change into a more structured and managed future, such as that provided by contingency planning, a type of planning that can be linked to the concept of discrete event simulation described by Tommelein et al (1998). Controversially, Ballard (1999) claims that the under-loading of work assignments leads to improved productivity: more mistakes are made when assignments are too large, thus less rework is required on smaller, more realistic tasks. Alarcon and Ashley (1999) advocate ACP planning in an ideal world, but comment that it appears difficult within the present framework and culture of the construction industry. Instead, they recommend the inclusion of buffers in the project plan to allow workable assignments and regard ACP as a technique for the future.

Supply chain management (SCM), was first established at Toyota in the 1960's (Womack and Jones 1996) and its successful implementation has led to its wide use in a range of industries. Barker et al (1999), describe the main elements of SCM as information flow, order fulfilment and product development with faster response times, less waste, more effective information flow and smaller amounts of inventory on site. Three case studies carried out in Finland and the Netherlands show difficulties in implementing SCM in the construction industry. It was found that although all parties to the supply chain professed to be operating a JIT structure, on closer examination each participant had an in-built time buffer for unforeseen over-runs (Tommelein and Li 1999).

Studies in the production industries (Womack and Jones 1996) and current research in the construction industry (Hong-Minh, et al 1999) suggest that to achieve the benefits described above, construction companies must undertake a supply chain engineering programme. Co-ordination must extend beyond first tier suppliers if a truly efficient environment is to be created (Womack and Jones 1996).

Recent attempts to improve efficiency and reduce conflict have involved the use of partnering. Although there is no universally accepted definition of partnering, it can be considered as forming allies through long term relationships, which rely on trust and understanding of common goals and objectives (Howell et al 1996, Barlow 1996, NEDC 1991). To date, research has shown that construction industry performance has been improved by the use of partnering (Cooper, et al 1996). By partnering the supply chain, companies are building a framework to reduce cost and time in the construction process which is achieved by reducing the disruption caused by delay and conflict between the individual parties (Cooper et al 1996). Contractors and clients alike appear keen to avoid the traditional adversarial culture of the construction industry by adopting the principles of teamwork and shared goals (Howell et al 1996).

FUNDAMENTAL ATTRIBUTES OF A LEAN APPROACH- A SUMMARY

Implementation of lean techniques is facilitated by an enabling procurement system with a significant emphasis on concurrent design and construction. Throughout the process planning techniques that are more structured and certain than critical path analysis, such as ACP, are required. Control techniques, such as lookahead schedules and 'last planner', which quickly identify programme variances, are important elements.

The management of inputs to the process was identified as being instrumental in the successful application of lean techniques in construction. Emphasis is placed on the effective management of primary service providers such as subcontractors, suppliers, and consultants, with whom close relationships serve to reduce adversarial situations. Another benefit of this was the identification of overlaps between services and the ability to manage all players as part of a single process therefore reducing the fragmentation associated with construction projects.

These fundamental attributes form a conceptual framework, against which all data obtained from main study survey was tested. Figure 1 shows a graphical representation of the framework.

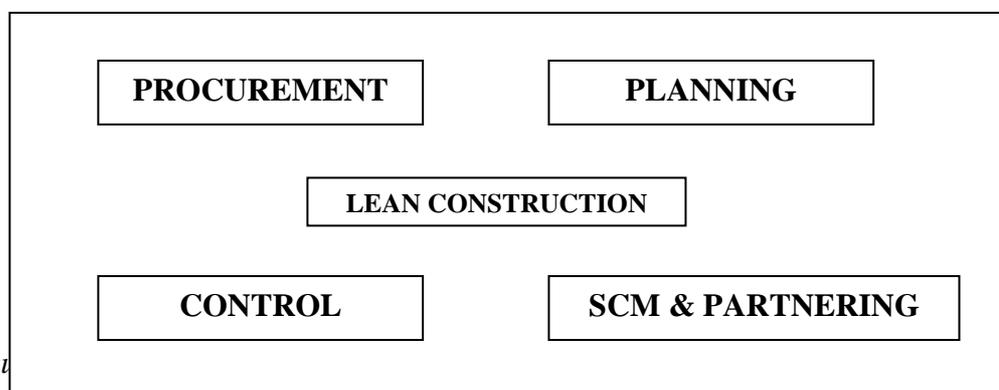


Figure 1

SURVEY DESIGN AND MEASURING OBJECTIVES

Anecdotal evidence suggests that lean techniques in construction could be limited, and the objective was to test this.

Data obtained from the DETR (1999) established that there are currently 221 'large' construction companies operating within the UK. Fifty of these companies were asked to participate in a pilot study: only seven replied, and ultimately only four completed questionnaires were received. However, the pilot was useful in allowing the main study questionnaire to be structured in a format that was unambiguous and simple to complete. The questionnaire was constructed to allow the identification of inconsistencies in interpretation and understanding of the fundamentals of Lean Construction among respondents. The questions were based around the issues identified in the conceptual framework shown in figure 1. This allowed the evaluation of the variables within the respondents' company, including the application and level of development of lean techniques. The questionnaire also established whether the respondent companies considered themselves to be practising lean construction and if they did, to what level was it currently developed. One hundred questionnaire surveys were then sent out and 34 were completed and returned.

The data obtained from the questionnaire were subjected to content analysis prior to an interpretative analysis. Pattern matching of the data was undertaken to allow detailed content to be categorised. Categorisation was based on a set of positive, negative or neutral keywords such as *Progressive*, *Developing*, *Advanced*, *Disadvantaged*, *Progressive*, *Restrictive*, *Enabling*. This allowed responses to be related to each other and the conceptual framework. Using interpretative matrices, the categories were then interrogated regarding inconsistencies, omissions, contradictions and correlation's relative to lean construction concepts. The aim was to establish the extent that each company had applied lean construction techniques. In addition, an analysis of what their personal perspectives were on the contribution of these techniques in developing a lean system would assist the accurate interpretation of the findings. This was achieved by comparing the contents of the questionnaires against the issues developed in the conceptual framework. The correlation between the conceptual framework and the contents of the questionnaires would ultimately establish the applicability of the techniques identified and the level of lean development within the company.

A further objective was to evaluate the level of penetration of lean techniques: whether they were pervasive throughout the organisation, or had, for example, been contained in upper management (e.g. boardroom) levels. This was determined by categorising the respondents' selection of specific criteria into systems, management and production based techniques. The level of penetration could then be ascertained from the focus given to the above categories, which could subsequently be attributed to the roles of company personnel. Following the completion of the content analysis and subsequent interpretative analysis, it was possible to establish whether UK contractors were fully embracing the concepts of lean construction or if they were merely applying some of the principles that exist in a lean industry. This was achieved by relating the existing systems of each company to that of the conceptual framework, with the premise that any inconsistency between the framework and structure of the existing system would impair the ability of the company to be practising lean techniques.

SURVEY RESULTS

The inconsistencies in the majority of the returns indicated a clear misconception of lean techniques.

The survey revealed that traditional contracting was still the primary route of procurement for most contractors. This contradicts the assumptions underpinning the conceptual framework, which identify the need to change from a process exchange model to a system that supports the use of concurrent engineering principles. Only two of the contractors from the study substantially procured using a design and build form of procurement which theoretically should provide an ideal situation to apply lean techniques. However, even for these two, the analysis of subsequent sections revealed the application of non-value adding techniques in other disciplines further down the line. The "leaner" methodology of using in house designers was also uncommon. In the main, the design element of design and build contracts was sublet to consultants. Another common theme throughout the analysis of the data was the inconsistency in planning techniques applied to construction and design activities.

One of the most revealing results was the professed application of lean principles within the individual companies. There was a combination of techniques which were thought "lean" but which added waste to the process. Critical path planning, which has been identified as a waste producer, was a technique used by many respondents. For a minority, this was coupled with lookahead planning and last planner techniques, which should help reduce inherent uncertainty. Some respondents chose only lookahead planning or last planner as a stand alone planning tool, however these can be considered control tools implemented on developed programmes and a clear anomaly could be identified here. Even more notable were those who did not identify the use of any techniques included within the survey options, but still professed to be applying lean techniques in some form.

Partnering was claimed by a large number of contractors, however this was primarily with subcontractors and suppliers. Client/contractor partnering is commonly entered into through the formation of long term relationships through negotiated tenders and repeat client requests, whereas the majority of contracts were identified as being tendered for on a selective tender basis.

The survey identified Constructing the Team (Latham, 1994) and Rethinking Construction (Egan, 1998) as drivers of change. While most respondents identified that action had been taken as a consequence of these reports, inconsistency with other sections was high. Both design management and planning were frequently identified as areas where no change had taken place. A similar pattern was evident with supply chain issues. The majority of respondents had reduced supply chain but some reported the opposite. The reduction of select lists of service providers is closely related to the application of partnering between parties. By reducing the numbers of service providers, better relationships can be developed and a larger percentage of work packages can be given.

In the main, respondents selected what could be termed a 'systems approach' to achieving customer value. Although most respondents identified the use of a systems approach in achieving lean principles, this was quite frequently found to be inconsistent due to the omission of fundamental contributors to the process. A typical response would be the use of design, partnering and quality assurance. Whilst all of these are applicable

to the process, they become ineffective if the role of planning is overlooked or the effectiveness of supply chain management is ignored. Some respondents consider a production system to be the most effective means of creating value. This system consists of site management, site production and contracts management. Again these are all value adding inputs to the process, but without the creation of a lean structure, which extends throughout the entire company and further still to down stream suppliers and subcontractors, the management of activities at site level will have little impact on the overall value of the process.

The survey also set out to identify whether demands for improvement have been put by clients upon contractors. The biggest demand from clients was lower costs and faster turnover of construction projects, direct benefits of a lean system.

A minority of respondents considered that the application of lean principles to construction is ineffective and that the demands from clients for quicker, cheaper projects can not be achieved in this way. This conflicts with studies of lean applications in overseas countries where project cost and time have been significantly reduced. To consider the overseas dimension, the survey identified those companies which operate overseas, to see if this has any impact on their development of lean techniques, but no significant association could be found.

The survey also sought to examine the effect of project value; this again, was shown to be insignificant to the development of lean techniques in the individual companies.

Respondents who claimed to be addressing lean techniques on a company-wide basis often demonstrated an inconsistent use of the techniques. Overall there were a number of such inconsistencies. A constant theme was the mix of traditional techniques with those that are considered lean. A typical combination was the use of traditional contracting, supply chain management and critical path planning. Both traditional contracting and critical path planning have been identified as contributors of waste in construction, thus reducing the effects of supply chain management. And yet the companies considered themselves to be applying lean principles on a company-wide and fully supported basis. The penetration of lean techniques in the companies management structure can be deduced from the level of lean activity throughout the company. The limited knowledge of lean techniques at boardroom level and subsequent use within construction projects suggests penetration into the management structure of most companies.

The selection of fundamental attributes by respondents varied widely. The consistent theme throughout the majority of questionnaires was the relevance of partnering and supply chain management to the lean process. Whilst these attributes do add value to the overall process, the use of partnering and supply chain management does not qualify a company as being lean. Few identified the importance of design and planning to the process of lean construction. These attributes are at the forefront of almost any construction project and failure to recognise these could be detrimental to the cost and time of the overall process. Issues relating to site management and production were seldom selected. This was a similar situation with the disciplines of contracts management and quality assurance. In respect of this, contractors may be justified in their choice. Although some of the available techniques do have more value adding potential than those identified above, they should not be dismissed, as they can ultimately offer benefits to the overall process.

CONCLUSION

This analysis of the level and application of lean construction within UK construction companies has revealed a distinct lack of understanding and application of the fundamental techniques required for a lean culture to exist. There appears to be significantly less lean culture in UK construction companies than is professed.

An even larger gap is evident from the level of development identified in the literature review in overseas countries. A good positive attitude emerged from the survey, but a more detailed analysis of the overall process is considered necessary to assist in the successful implementation of the techniques identified. Whilst it is considered that the application of further studies in the field of lean construction will ultimately create a greater understanding, there is a need for prompt action by contractors in order to benefit fully. An understanding of lean techniques can come from the literature and from the investment in training and development programmes. Once the concept of lean construction is fully understood, construction companies may begin a development programme involving all players who have a valued input into the overall construction process. This should extend to key service providers within the process such as subcontract companies, suppliers, consultants and ultimately clients. The development needs to be undertaken by a group of individuals and supported by top management which needs to afford both sufficient time and resources to achieve the anticipated gains associated with a lean process. Although the present study identifies the development and application of fundamental techniques in lean construction, further studies directed at the individual disciplines and their integration into the construction process are considered fundamental in the successful development of a lean culture. A starting point for the investigation into the development of lean techniques could be taken from the conceptual framework, which has been developed from the findings of the present study. It is anticipated that this will identify the main issues involved in lean construction, which will subsequently lead to a more detailed analysis of the individual disciplines involved. Current research suggests that the efficiency of the UK construction industry cannot be improved if the methods used to procure and manage construction projects remain the same. Lean construction provides the framework to instil a new mindset into all players of construction, providing a more efficient process with better gains for all involved. As more companies become involved in the lean transition, the level of development will increase and the culture that has existed for many years will gradually begin to change.

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