DEVELOPING A LEAN MODEL FOR PRODUCTION MANAGEMENT OF REFURBISHMENT PROJECTS

Sergio Kemmer[1] and Lauri Koskela[2]

ABSTRACT

Refurbishment is a subject that has received great attention within the current research agenda in the UK given that it has a crucial role to meet sustainable targets. The degree of complexity and uncertainties in refurbishment projects is higher than in new build projects. A literature review reveals that the management of refurbishment works has not been addressed properly in prior research. Studies on practices applied to the management of this complex environment are scarce and have not been based on appropriate theory. This scenario offers an interesting opportunity to apply lean principles in order to deal with its complex characteristics. However, while lean theory has been well tested in new construction projects, in the refurbishment sector the same level of practical application has not been undertaken or reported. It is argued that production management of refurbishment projects needs an appropriate approach, specifically tailored and in line with lean tenets, to be able to cope with the complexity and uncertainty inherent to those projects, hence increasing the efficiency of the production system, e.g., lead time compression and disruption minimization.

The research is done through an extensive literature review, which seeks to identify the methods adopted by refurbishment sector to deal with the production management as well as suggest lean practices for further testing and validation.

KEYWORDS

Refurbishment, lean construction, complexity, management, sustainability.

INTRODUCTION

According to the Climate Change Act (DECC 2008) the carbon emissions in the United Kingdom are targeted to fall no less than 80% (by comparison with a 1990 baseline) to 2050. It is known that the built environment is responsible for almost 50% of carbon dioxide emissions (Itard et al. 2008). Given that a considerable amount of buildings, estimated at approximately 70% (Ravetz 2008) that will be standing in 2050 has already been built, it is safe to say that the refurbishment process of the existing stock has a crucial role to meet sustainable targets.

This scenario has been driving researchers into the refurbishment area in order to address a number of issues. In this respect, a considerable amount of research has

[1] Research Assistant, School of the Built Environment, 4th Floor, Maxwell Building, Phone +44 01612955136, The University of Salford, Salford M5 4WT, United Kingdom, S.Kemmer@salford.ac.uk; sergiokemmer@gmail.com

[2] Professor in Theory Based Lean Project and Production Management, School of the Built Environment, 4th Floor, Maxwell Building, Phone +44 01612956378, The University of Salford, Salford M5 4WT, United Kingdom, L.Koskela@salford.ac.uk

been developed aiming at better understanding the way that refurbishment projects are designed, procured, built, and operated.

A search in the literature reveals that the studies undertaken involve topics that vary considerably in terms of research focus. For instance, there is research delving into the analysis of the building stock and its importance (Kohler and Hassler 2002, Itard et al. 2008), the government's policies for sustainable refurbishment and related issues (HM Government 2010, HM Government 2011, Mansfield 2011), the refurbishment demand and cost implications (Aikivuori 1996, Johnstone 2001, Chau et al. 2003), cost modelling (Lehtonen and Kiiras 2010), the use of information technology (Okoroh and Torrance 1999, Ho 2009), besides the engagement and perspectives of users in refurbishment projects (Holm 2000, Miller and Buys 2008).

However, there is a missing link in refurbishment's research agenda. Despite the vast number of research initiatives designed to better understand refurbishment sector aimed at improving its performance, the specific topic of the management of refurbishment works has not been addressed properly. Studies on practices applied to the management of this complex environment are scarce.

In this paper, more details will be provided concerning the research on the production management of refurbishment projects. The information was gathered through a literature review that sought to look at research focused on how refurbishment works are traditionally performed. Problems encountered in refurbishment projects are also mentioned.

In addition, the paper points out the importance in recognising the characteristics of the refurbishment projects in order to adopt a suitable approach to cope with this specific scenario. In this respect, lean construction is identified as an appropriate way to deal with the complexity and uncertainty inherent to such projects.

Lastly, a set of lean managerial practices based on the analysis of the literature as well as evidences from secondary case studies is suggested to be tested in refurbishment projects. Thus, this paper should be seen as a starting point for improving the efficiency in managing production of refurbishment projects.

THE TRADITIONAL APPROACH TO THE PRODUCTION MANAGEMENT OF REFURBISHMENT PROJECTS AND ITS IMPLICATIONS

The literature on the management of refurbishment projects is scarce. There are few studies reporting the way that construction companies have been managing production in such projects. The material produced by Egbu (1994), Egbu (1995), Egbu et al. (1996), Egbu (1997), Egbu et al. (1998), and Egbu (1999) represent the most wide-ranging analysis in the management of refurbishment works.

The study developed by Egbu (1994) delves into aspects concerning to the management of refurbishment works within the UK construction industry. Through semi-structured interviews with managers and a postal questionnaire addressed to refurbishment organisations, he got an overview of the particular issues and characteristics related to the management of this complex environment.

The analyses carried out by Egbu (1994) comprise different factors. For instance, variation/change orders to the works, keeping the site tidy, cost control, maintaining site safety & welfare standards, and programming and scheduling were identified as the most frequently occurring characteristics in managing refurbishment work. In turn, cost control, dust control, the influence of tenants on the regular progress of the

works, and variation/change orders to the works are identified as the most difficult refurbishment characteristics faced by managers.

Egbu (1995) also seeks to understand the degree of difficulty associated with managing refurbishment tasks. Forecast and planning, analysis of project risks and uncertainty, competitive tendering, budgetary control, and the ability in managing time were perceived as the most difficult management tasks in refurbishment projects.

Egbu et al. (1996) and Egbu et al. (1998) also identify the managerial practices used by refurbishment organisations. Data was collected through a case study approach in a hospital and hotel refurbishments. Table 1 illustrates the planning and control techniques most applied to manage refurbishment works.

Table 1: Frequency of use of formal planning and control techniques (Egbu et al. 1996, Egbu et al. 1998)

Rank	Planning and control techniques used in a construction refurbishment (e.g. hospital project)
1	Schedules
2	Critical path method (CPM)
3	Project cost-value reconciliation
4	Bar chart
5	Milestone date programming technique
6	Labour (actual versus forecast) reconciliation
7	Plant (actual versus forecast) reconciliation
8	Materials (actual versus forecast) reconciliation
9	Computer: expert system techniques
10	Programme evaluation and review techniques (PERT)

Clearly, Table 1 shows that production planning and control in refurbishment projects has used traditional techniques such as Critical Path Method (CPM), Programme Evaluation and Review Techniques (PERT), and Gantt charts.

Some could contend that Egbu's research is outdated, implying that the management of refurbishment works has improved since then. However, there is no evidence of this; on the contrary, there are some examples that show that it has not. A recent study developed by Henrich (2009) shows clearly that the practices applied to manage production in refurbishment projects remain inappropriate. As a result of this approach to project management, the project performance is often unsatisfactory.

Henrich (2009) conducted an analysis in two construction companies based in Greater Manchester to identify cases of low performance and waste incidence at construction sites. Both companies investigated were carrying out refurbishment projects. The first case study was a transformation of a 4 storey old mill into a block of 180 residential apartments. The second one was a regeneration program funded by a government association comprising 600 houses.

Findings from those case studies confirm that traditional planning approaches are still the basis for the production management. For instance, planning is centralized and contains excessive details at early stages. There is a lack of involvement of stakeholders (managers, subcontractors, suppliers, labourers, etc.) in the creation of plans and the Critical Path Method (CPM) based software packages are used to define the critical path and estimate project duration.

In addition, managers use pre-estimated plans to push activities to the production regardless the system status and the communication between planning and production is done in a one-way fashion. Besides, there is no evidence of a continuous improvement programme implemented on site (Henrich 2009).

As a result of the use of inefficient production management methods, Henrich (2009) identifies several types of waste within those two refurbishment projects. They refer to waiting time, the use of wrong equipment, rework, unnecessary transport, double handling, space conflicts between materials, equipment and assembly crews, and disruptions during refurbishment works. The wastes resulted in low productivity, project delays, and tenant's annoyance.

Problems in managing refurbishment are not only identified in England. For example, Krizek et al. (1996) carried out an investigation in a multiphase reconstruction project in the United States and pointed out difficulties in communication between project members as well as problems to manage production leading to schedule overruns. McKim et al (2000) conducted a survey in Canada and reported the poor performance of reconstruction projects in terms of cost, schedule, and quality, in comparison with new building projects. In both studies, managerial tools such as Gantt charts and CPM were reported as the main techniques adopted.

Ruohomäki (2006) reports challenges faced during the planning of a renovation building in East Finland such as the lack of shared understanding of the project team, missing leadership, and weak communication. Also in Finland, the research carried out by Naaranoja and Uden (2007) involved four renovation projects and reveals that problems such as time and cost overrun, defective work, and failure in fulfil customer requirements. The use of inefficient project management systems is pointed out by the researchers as one of the reasons for the problems encountered in those construction projects.

In conclusion, as noted by Henrich (2009), the construction industry has been using either outdated production methods or using them in a wrong context. As a result, those methods lead to production wastes and a decrease in project performance.

The argument made by Henrich (2009) brings to the discussion the importance of understanding project context in order to devise an appropriate approach to cope with it. In line with this, Egbu et al. (1998) also stress that "*the process of planning should be adjusted to fit project characteristics*".

Therefore, the next section summarizes the characteristics of refurbishment projects with the purpose of recommending the appropriate theoretical basis to be used in the production management of these types of construction projects.

FIT FOR PURPOSE – LEAN CONSTRUCTION AS A WAY FORWARD

Refurbishment works have different features in comparison with new build projects. The management of refurbishment works is complex, highly specialized, risky, and uncertain, hence more difficult to manage than new build. It contains elements of works which are unique to refurbishment and different from new building work (Egbu et al. 1996, Egbu 1997, Egbu et al. 1998).

Unpredictability is another issue found in refurbishment projects. The extent and problems of the work are not discovered until demounting and stripping work have commenced. Besides, there is a lack of "as built" drawings to guide designer and

builder (Quah 1992). Also, small labour intensive operations scattered throughout the existing buildings, often with tenants in occupation (Quah 1992, Ho 2009).

Undoubtedly, the management of refurbishment projects is complex. Egbu (1995) and Egbu et al. (1996) pointed out that those projects need appropriate managerial methods, tools and techniques. Egbu et al. (1998) argued that "*refurbishment works demand an ability to deal with non-continuous and complex processes*".

Actually, the subject of project complexity has been focus of several studies (Baccarini 1996, Laufer et al. 1996, Williams 1999, Beckerman 2000, Bertelsen 2003, Bertelsen and Koskela 2003, Bertelsen et al. 2007). These authors recognize the difficulty that construction industry has to deal with the increasing complexity in construction projects. They also pointed out the importance in recognising it in order to devise appropriate approaches to project management.

For example, Baccarini (1996) points out integration as a way to deal with this scenario. Laufer et al. (1996) recommend a project management style based on elements such as integration, systemic management, simultaneous management, and the use of high-tech information technology.

Bertelsen (2003) and Bertelsen and Koskela (2003) also recommend the use of a complexity approach for improving the understanding of the construction processes. As a result, new approaches to project management emerge for organizing, planning, and controlling the process. In line with this, Bertelsen et al. (2007) highlight the importance to develop tools for managing all the flows existing in construction.

The authors of this paper argue that the lean philosophy is the appropriate way to deal with the complexity and uncertainty inherent to refurbishment projects, given that this management philosophy integrates the transformation, flow and value views (Koskela 2000). Several studies in construction management have been considering this conceptual framework to design and manage production systems in a more systemic perspective (Howell and Ballard 1999, Ballard et al. 2001, Schramm et al. 2004, Schramm et al. 2006, Ballard 2008).

The lean philosophy has also a better approach regarding waste in comparison with traditional management. It is largely acknowledged that the seven types of wastes identified by Ohno (1988) underpin lean principles. Waste reduction is primary in lean systems.

In addition, Koskela (2004) argued that there is an eighth type of waste, which he nominated as "making-do". It refers to situations where the production starts without all prerequisites necessary to perform the task, and also when works on site continue even when any of those requirements has ceased.

Lean theory also presents a set of appropriate methods, tools, and techniques which have already been successfully implemented in construction projects. However, there is limited evidence regarding practical applications of lean theory in refurbishment in comparison of what is found concerning new building projects. In the next section, the authors of this paper report studies that somehow use lean concepts and principles to improve the management of refurbishment projects.

TOWARDS A LEAN APPROACH TO THE PRODUCTION MANAGEMENT OF REFURBISHMENT PROJECTS

While lean theory has been well tested in new construction projects, in the refurbishment sector the same level of practical application has not been undertaken

or reported. In fact, there are few examples in the literature of lean initiatives to improve the performance of refurbishment projects. Table 2 presents studies that somehow use lean principles to deal with management of refurbishment projects.

Table 2: Evidences of Lean principles applied to refurbishment projects.

Authors	Research developed
Mitropoulos and Howell (2002)	The researchers examine the problems that occur during the design phase of an office renovation project and offer strategies to reduce design rework and duration as well as increase quality of the design solution. They refer to early involvement of key project members, prototyping, the identification of key constraints, and an accelerated discovery of existing conditions of the building.
Horman et al. (2003)	Discuss the use of buffers in production planning and control in the Pentagon Renovation Project. The planning method used in the project segmented it into small batches to improve production workflow.
Singh (2007)	Proposes a framework for production management of renovation projects based on methods to quantify the impacts of constraints on production schedule. The approach aims at improving schedule performance.
Tuholski and Tommelein (2008)	Advocate the use of the design structure matrix (DSM) methodology on a seismic retrofit project and demonstrate that it is useful for optimizing design process. The transparency provided by the use of DSM helps practitioners to identify interactions at different levels improving considerably the communication within design process.
Tuholski et al. (2009)	Demonstrate the usefulness of cross-functional process charts for improving project delivery process in two complex retrofit projects where seismic isolation bearings were installed. The charts serve as a tool for representing project complexity in order to enable project participants to identify opportunities for improvements.
Ho (2009)	Develops an automated method to identify interactions between tenants and crews in renovations of occupied buildings in order to reduce disruptions on site. This is made possible by a better understanding of the dynamic nature of renovations projects along with the use of a computer-aided prototype.
Lahtinen et al. (2009)	The intervention implemented is characterised by the user's engagement in the renovation process, the formation of a multi-disciplinary team in order to bring different perspectives to the project environment, and the use of several channels of communications between users and project team (e.g. informative meetings, visits to the construction site, webpages containing project information such as schedules, etc.).
Pereira and Cachadinha (2011)	The authors assess the application of lean techniques for managing production in rehabilitation works. This refers to the use of value stream mapping, pull planning, 5S, etc. Conclusions indicate that it is possible and useful to apply lean techniques in this context. Also, the study indicates that there is a room for further improvements in this area.

The studies mentioned above prove that lean principles can be applied to improve performance of refurbishment projects. Also, they indicate that a proper understanding of the context of refurbishment projects is vital to devise appropriate solutions to this particular project environment.

Another primary aspect observed in those studies is the use of managerial practices that consider principles of flow process design and improvement. For instance, value stream mapping, cross-functional charts, design structure matrix, early involvement of key project members, last planner system, prototyping, and 5S can be

considered as means to take into account lean principles such as pull planning, process transparency, continuous flow, collaboration, learning, and improvement.

In addition to the literature on lean refurbishment, there are also examples of lean implementations in construction projects that have similar characteristics in comparison with refurbishment in terms of project complexity.

For instance, the studies developed by Schramm et al. (2006) and Cuperus et al (2010) do not refer directly to refurbishment projects, but they approach construction projects with complex characteristics, akin to the refurbishment context. Both cases demonstrate that significant benefits can be achieved through the use of managerial practices in line with the lean tenets such as Last Planner System, Visual Management, Line of Balance, among others. Clearly, lessons can be learned from those experiences in order to improve the way that the management of production in refurbishment projects is performed.

It is worth mentioning that the refurbishment sector comprises different types of projects such as houses, hospitals, offices, department stores, etc. In this respect, a couple of questions emerge: How should a specific type of project be approached from a lean perspective? Does every lean practice suit to any type of refurbishment project? Presumably, there are different approaches to different projects.

Therefore, it is worth to investigate the usefulness of the lean practices across the different types of refurbishment projects. To this end, based on the analysis of the literature as well as evidence from secondary case studies, a set of managerial practices is suggested as candidates for initial testing. They are: Collaborative Design, Target Value Design, Production System Design, Last Planner System, Line of Balance, Visual Management, Cellular Manufacturing, Multi-skilling, Prefabrication / Standardisation, Mass Customization, and Benchmarking.

CONCLUSIONS

This study reveals that the management of refurbishment works has not been addressed properly in prior research. Studies on practices applied to the management of this complex environment are scarce and have lacked a theoretical underpinning.

The traditional planning systems normally used by construction organisations neglect the characteristics of construction projects; hence the project performance in construction projects, including refurbishments, remains unsatisfactory.

Lean theory is argued to be the appropriate theoretical foundation to cope with complex environments like refurbishment projects. Recognising the uncertainty inherent to those projects and reducing it by using appropriate managerial practices is vital to mitigate the negative impacts that variability brings to the project environment.

The literature demonstrates that the use of managerial practices based on lean concepts and principles is appropriate and useful for managing production of complex construction projects, including refurbishments. Moreover, they illustrate the huge potential for increasing efficiency in production systems as well as in improving project performance.

From the research on lean applied to refurbishment projects, lessons could be learnt that are indicative of success in project management. First, a better understanding of the context of different types of refurbishment projects is necessary in order to identify the appropriate managerial approach for each kind of project.

Second, the methods, tools, and techniques used for production management of refurbishment projects should be based on a lean philosophy.

However, while the results from lean implementations are encouraging, especially in new building projects, there is limited evidence of practical application of lean within refurbishment sector. Clearly, there is a room for exploration as to how lean philosophy can be applied to innovate and improve the way that production management of refurbishment projects is performed.

A list of methods, tools, and techniques for managing production systems is presented in this paper and should be tested by construction refurbishment organisations in order to improve efficiency in managing production of refurbishment projects. Evidently, the best way to assess the efficacy of the lean approach is experimenting. It is by practicing and testing that the necessary awareness to attain a continuous improvement is developed.

To conclude, this study should be seen as work in progress with much more to learn, as detailed research work around the sustainable refurbishment process in a lean way, particularly in the context of field studies. Further developments are expected in the near future, when primary research in this area is further developed.

FURTHER RESEARCH

Additional work is needed in order to better understand the characteristics of refurbishment projects and also to comprehend how these features affect the implementation of the lean model in such projects. Some initial questions for further investigation and discussion are presented in the following:

What is the pattern of production processes in the refurbishment sector? What are the opportunities for improvement in the refurbishment processes from a lean perspective?

Is it possible to create taxonomy of refurbishment projects in order to devise templates for production management tailored according each category?

What kind of wastes exists in the production management of refurbishment projects? How representative are they?

How the adoption of lean philosophy can reduce disruptions, hence durations of refurbishment projects?

What are the enablers and barriers to adopt lean practices in refurbishment projects?

To what extent the adoption of lean practices for managing production in refurbishment projects might influence project performance?

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