

CONSTRUCTION MANAGEMENT AND LEAN THINKING IN HIGHWAYS MAINTENANCE

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The Highways Agency (HA) has recently rethought the way it commissions maintenance work on the trunk roads and motorways for which it is responsible. Taking on recommendations from recent reports into the UK construction industry, the HA have introduced the Construction Management Framework (CMF) in Areas 9 and 10 which covers a large area of the UK from Herefordshire to Lancashire. The CMF looks to implement substantial changes in culture and structure through replacing competitive tendering with long-term relationships and partnering based on quality rather than cost. The aim of this paper is to explore how the CMF can achieve its aims to provide best value and continuous improvement in comparison to traditional methods of procurement. On an operational level, lean construction has been identified as one means of providing best value within the CMF. This paper will assess how lean thinking lends itself to the core objectives of the new culture that the HA are promoting. It will consider how lean construction can improve best value within the CMF, with the intention that the need for further research will be identified. The paper is mainly based on a literature review that forms part of the first phase of an Engineering Doctorate, which aims to compare procurement methods and assess the merits of lean thinking in highways maintenance.

Keywords: continuous improvement, highways maintenance, lean, partnering, procurement.

INTRODUCTION

Construction management was first adopted by the Highways Agency (HA) as an innovative procurement strategy in 2002. This paper is based on a literature review that forms part of the first phase of an Engineering Doctorate aimed at assessing construction management as a procurement method, and exploring the use of lean thinking in highways maintenance, under the construction management framework arrangement. It explains how this arrangement facilitates the delivery of more efficient and effective services and aims to fulfil objectives set out in recent studies demanding improvements in the construction industry. Action-based research into the performance of construction management and the implementation of lean practices in highways maintenance will be carried out to complete the Doctorate programme.

BACKGROUND TO THE HIGHWAYS AGENCY

The establishment of England's trunk road and motorway network in the 1930s, its growth into an asset worth over £65 billion and the development of the Highways Agency (HA) in 1994 to manage and maintain the network is well documented (Haynes and Roden, 1999; Highways Agency, 2001; Highways Agency 2005c). The

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HA was created as an executive agency for the Secretary of State for Transport, Local Government and the Regions in response to demands in the 1980s and early 1990s to improve the efficiency of the public sector by making the best use of both public and private resources. When the HA took on its executive agency role, there were 91 different agency agreements in existence for carrying out maintenance of the road network, which covered the management of routine, winter and capital maintenance, and other duties such as inspections of the network, accident investigation and data provision. Of these agreements, 85 were with local highway authorities, and the remainder with private sector consultants. One of the requirements for the HA when it began was to review these agency agreements, with the intention to increase opportunities for the private sector to become involved in the works. Following a consultation exercise in 1995, it was announced that the number of agency areas was to be reduced from 91 to 24, and the agency agreements would be open on a competitive basis to both the public and private sector. This was later reduced to 14 areas.

KEY STUDIES INFLUENCING HA PROCUREMENT

The HA recognised that major studies in the last decade had highlighted problems with traditional methods of procurement in the highways sector. The reports made various recommendations for improving the industry, focusing on the problems in the UK construction industry, in particular the poor relations between clients and their supply chain. Targets and recommendations for improving productivity were linked to better use of partnering and more innovative forms of procurement, such as design and build (Latham, 1994; Egan, 1998; National Audit Office, 2001). In addition, Egan suggested that lean thinking is the biggest opportunity for improving productivity. Reports on behalf of the government as a client (Levene, 1995; Gershon 1999) looked to better training in procurement and understanding of value for money for its personnel.

While there may be some scepticism of the targets set out in the reports, particularly Latham's call for 30 per cent improvement in productivity, many of the recommendations have been recognised as best practice and preferred methods of working. Partnering and collaborative working is often seen as offering competitive advantage (Blayse and Manley, 2004; Ledger, 2003; Stanek, 2004; Highways Agency, 2005a). However, criticism of partnering points to the fact that the task force led by Egan comprised employees/representatives of client organisations, and partnering is perceived by some as simply a crude exercise in buying power, in which suppliers must buy into the partnering culture or risk alienation from the significant portion of the UK market that embraces partnering (Green, 2002). Green (p178) suggests the claims that partnering replaces the regulated market economy with corporatism and conflicts with principles of humanism are exaggerated; however evidence that he presents of cases where partnering has led to high staff turnover or where savings have not been passed on to the customer illustrate that partnering may not be the panacea that it can first seem.

Egan's demand for performance measurement systems and the use of key performance indicators (KPIs) has also been widely adopted (Audit Commission, 2000a and 2000b; Constructing Excellence, 2005). The guidelines for what to measure are set out in these documents to align with the targets given by Egan, however, the method of measurement is not defined because of the different sectors and nature of works within the construction industry.

HA PROCUREMENT

The above reports reinforced the knowledge that in the early 1990s the outturn cost of projects was on average 24 per cent higher than the original tender price; this had continued to rise to 40 per cent on more recent projects procured using traditional methods (National Audit Office, 2001). In addition, the HA were concerned that they were creating adversarial relationships with suppliers that was not sustainable. Taking on board the recommendations from the reports, the HA prepared a procurement strategy based on ten overlying principles to achieve best value (Highways Agency, 2001), including: early creation of the delivery team; integration of the supply chain with longer-term relationships based on continual improvement targets; clear points of responsibility to improve the scope for partnership working; selection of suppliers based on best value, with optimal combination of quality and price for awarding contracts; fair allocation of risks; and performance measurement with continual improvement targets.

HA Contracts

The HA divided their work into four categories for procurement purposes as shown in Table 1 (Highways Agency, 2001). From the late 1990s, the HA began to use the New Engineering Contract (NEC) on all works contracts, with new contracts awarded on the basis of quality and price. Project partnering arrangements were adopted on many contracts within the regional and major projects categories, and framework contracts have been used where it is considered there is an adequate workload of a consistent and continuous nature.

Table 1: General indication of division and responsibility of HA work (for procurement purposes).

	Maintenance contracts		Regional projects	Major projects
	< £250,000	< £500,000	< £5 million	> £5 million
MA and TMC	✓			
MAC	✓	✓		
eMAC	✓	✓	✓	
Construction Management			✓	
Single point frameworks			✓	
Design and build				✓
Early design and build				✓
Private finance initiative (PFI)				✓

When the agency areas were first opened to the private sector, separate managing agents (MA) and term maintenance contractors (TMC) were contracted to provide maintenance services. In 2001, a new form of maintenance contract was introduced by the HA in the form of the Managing Agent Contractor (MAC) contract, which achieves a single-point responsibility, a form of prime contract which is favoured by the Office of Government Commerce (Highways Agency, 2001). MAC contracts are currently in effect in eight agency areas, with the original intention being that all areas would be managed under this arrangement. However, the HA's procurement strategy is evolving, and the first enhanced MAC, or eMAC, was awarded in December 2004, which allows the eMAC to carry out work up to a value of £5 million including regional projects as well as maintenance. More recently, a consultation paper has been released for comments on a new form of contract: the PFMAC, which aims to combine the flexibility and partnership ethos of the MAC with the whole life and single supplier approach of the DBFO. It is intended the PFMAC will be structured

around the delivery of ongoing maintenance and operation services on the network, rather than a specific construction scheme (Highways Agency, 2003).

The procurement strategy aims to provide a consistent approach to procurement throughout the HA. It looks to long-term partnering and better awareness of its supply chain to address the adversarial culture that had previously existed, and it aims to focus on quality through the selection criteria of its suppliers, allocation of risk and reward, and performance monitoring. The strategy is seen to be a success with the “MAC model” now being adopted by local authorities (Highways Agency, 2005a).

Construction Management

To further promote integration and gain an understanding of the issues affecting the supply chain in its delivery of best value, the HA considered using Construction Management (CM) in renewal and improvement schemes. CM operates on the bases that the client has direct contractual relationships with each of its works contractors, and a separate contract exists with a construction manager. The construction manager is paid professional fees to act as the client’s agent in co-ordinating and supervising the project (Construction Management Forum, 1991; Murdoch and Hughes, 2000; Highways Agency, 2001; Oyegoke, 2001). Tate (2003) produced a matrix for principal standard forms of contract where the JCT CM contract allows a high degree of client involvement, flexibility and speed, with low cost certainty and clarity of remedial repairs. The guide does not show a CM contract based on the NEC, as used by the HA. Gray (1996) recognised that CM can bring benefits beyond cost competition, including flexibility and quality. He noted that it is important to select a competent construction manager to manage the design and construction process, and highlighted the trust that must exist between all parties to gain the full benefits of CM. He also noted that there is a learning process involved in using CM, and the full benefits are often not realised until the second or third project. However, he does not say whether the entire CM team is used on subsequent projects, or if the learning is on the part of the client.

The HA introduced CM in two pilot schemes, followed by the introduction of the first CM contract in 2002, as discussed below.

CMP – the first CM pilot scheme

A 12-month long pilot scheme (CMP) started in April 1999 in the North West of England. The works contractors, termed specialist framework contractors, had an early contractor involvement (ECI) in projects with input at the design stage, and the CMP required an on-going interaction among the stakeholders during the handover and operation stages. Key lessons learnt were discussed on completion of construction in reviewing the project’s performance, thus ensuring project team members continually improve. Key performance indicators (KPIs) were established at the beginning of the pilot scheme. These included measures beyond cost, quality and time objectives, such as the client’s involvement in the project, and the extent to which consultants and contractors had shared knowledge, expertise and resources during the design stage (Highways Agency, 2005b).

Bryde and Brown (2004) interviewed five individuals from different stakeholders involved in the CMP. All individuals believed that the CMP procurement strategy produced more successful project outcomes in comparison to traditional procurement strategies. The interviewees identified a number of critical success factors relating to their project, including establishing relationships based on trust and mutual respect,

establishing clear communication channels and gaining senior management commitment. Commercial cost benefits were not explored in the research.

CMP2 – the second CM pilot scheme

CMP2 was a two-year project involving a £40 million programme of works in four Maintenance Areas. Contractors were selected for the first time on an 80/20 quality/price basis, with “quality” including an assessment of the organisations’ attitude to the partnering philosophy. A number of “off-line” Community groups were established, such as the Pilot board, the Pilot Issues Group, the Newsletters and review meetings, and the Measurement Process. It was expected that representatives from all stakeholders would participate in the off-line groups. The team was also encouraged to form a self-supporting “Community” to resolve difficulties, promote best practice and bring “peer pressure” to bear on any individual company in danger of failing to meet its obligations. Early contractor involvement (ECI) was adopted, with the supply chain also being involved in the design and development of schemes. KPIs were agreed in early workshops, and a comprehensive set of measures devised and applied across the project. In addition, the concept of derived pricing was introduced, with prices for work agreed/derived on resource outputs as opposed to a schedule of prices (Highways Agency, 2005b).

CMP2 was considered to be a success, with KPI results showing the scheme equalled or bettered conventional procurement in 90 per cent of the measures (Highways Agency, 2005b). Despite a steep learning curve, projects were delivered at competitive prices in a way not possible under traditional forms of procurement. The HA were subsequently awarded *Client of the Year* in the Contract Journal Annual awards in 2001 for their work in CM (Highways Agency, 2005b).

CM Areas 9 and 10

In July 2002, CM contracts were awarded in Areas 9 and 10 for renewals and improvements schemes, amounting to around £350 million over 4 years (with an option to extend the contract to 7 years). The 24 companies involved in the CM Framework comprised the two highways agency areas, a construction manager in each area and 20 specialist framework contractors across nine disciplines. These companies formed a CM Community (CMC) defined in a manual produced by the CMC (Construction Management Manual, 2002, p3) as: “A collection of companies and organisations, bound together by a series of collaborative processes and principles that have formed a unique community delivering a service to the Highways Agency under the route of Construction Management in Areas 9 and 10”. The CMC members agreed a single overall vision: “To deliver an industry leading performance through partnership, co-operation and commitment”, and it has off-line groups to take ownership of driving the strategies to deliver objectives in line with the vision. Annual reports have been produced in 2003 and 2004, detailing progress made in the year, and figures on improvements. In 2004, some of the achievements noted were a nine percent improved performance in deliver of output goals, self-assessment scores showing on average 27 per cent improvement in delivery across six goals, and an independent pricing exercise demonstrating a cumulative saving of one per cent under CM, compared to anticipated alternative costs (Construction Management Framework, 2004).

In addition to considering total outturn costs, KPIs evaluate comparison of actual costs against agreed target prices, as well as information to show continuous improvement, such as safety, customer satisfaction, defect free work, time predictability, team

performance and final account settlement. Improvements in the KPIs account for the nine per cent improvement in the delivery of output goals. Whilst the measures are constantly being reviewed and updated, they are currently the main basis for providing evidence of continuous improvement within the CM framework.

However, research is required to assess the suitability of the measurement currently being used and evaluate the real performance of the CM framework. There is little project-specific research into the use of CM; none at all has been found in highways maintenance, or of a framework setting, while there remains some doubt of its advantages. An action-based study will be conducted to establish the suitability or otherwise of using CM for highways renewal and improvement schemes. In addition, as mentioned earlier, lean thinking has been highlighted as the biggest opportunity for improving productivity (Egan, 1998). This will form an additional study.

LEAN THINKING IN CONSTRUCTION

Similarly to Egan, Koskela et al (2003) suggested that while ensuring the most appropriate procurement method is used, changes to operational processes where the end product is created (design, prefabrication and site) would be more effective. It is at this stage where costs, quality, safety etc. are concretely formed, so gains from changes would be swift and visible. In addition, by effecting the change at the operational level, knowledge can be gained of what needs to be changed upstream and in the superstructure of procurement modes, contracts, information systems, etc.

Origins of lean thinking

Lean construction has been recognised as a tool for improving processes and adding value by both the HA and the CM community. Evidence of the use of lean thinking in other sectors of construction has shown there are benefits to be made from applying lean principles to highways (there are many contributors to literature of lean construction, among them: Howell, 1999, Ballard, 2000, Koskela, 2000, and Bertelsen 2002). The literature recognises that lean began in manufacturing by Jim Womack to describe Engineer Ohno's ideas towards eliminating waste taking principles used to satisfy high demand for a standard product, and applying them to build to specific customer order. Five principles for lean production were widely adopted in manufacturing in general: precisely specify value by specific product; identify value stream for each product; make value flow without interruptions; let the customer pull value from the producer; and pursue perfection. The guiding principle is the optimisation of the flow of value towards the customer and lean thinking in manufacturing has continued to focus on the end product.

Lean construction theory

Construction has been frequently identified in the literature as a complex process to deliver a one-of-a-kind product through cooperation of a temporary, multi-skilled team. Two major contributions to lean construction are Koskela's Transformation-Flow-Value (TFV concept) (Koskela, 2000) and Ballard's Last Planner system of production control (Ballard, 1999), followed by Ballard and Howell's lean project delivery system (LPDS) (Ballard and Howell, 2003).

Koskela's TFV concept considers value and waste generated in specific operations (transformation) and activities between operations (flow), and involves identification of true value to the client throughout the process (value generation). Lean thinking forces a focus on maximising value and eliminating waste.

The Last Planner system concentrates on the planning function of construction, using a sliding window (Lookahead Plan) to plan what can be done when constraints are removed. An important function is the Percent Planned Complete (PPC) which monitors the Lookahead Plan and requires reasons for delays, which are analysed in terms of root causes.

The LPDS is a project management tool that redefines project phases into project definition, lean design, lean supply, and lean assembly and use. Project definition includes defining customer and stakeholder purposes and values, design concepts and design criteria. Lean design defers decisions until the last responsible moment in order to allow more time for developing and exploring alternatives. Lean includes initiatives such as reducing the lead time for information and materials. Lean assembly describes delivery of materials and relevant information for their installation, to the moment that the client has beneficial use of the facility.

The literature, which is obtainable from the International Group for Lean Construction and the Lean Construction Institute, is largely theoretical. It is based on the assumption that the lean principles which apply to the manufacturing industry can work as well in construction, without changing the fundamental nature of construction. However, planning in construction is suspect to many variables, some of which are uncontrollable, and contextualisation of lean manufacturing theory is required if the full benefits of lean thinking are to be realised by the construction industry.

Lean construction in practice

Where lean construction in practice has been researched, improvements have been documented. The construction lean improvement programme (CLIP) was sponsored by the Department for Trade and Industry. It looked at the theoretical principles of lean construction and made attempts to turn it into a practical tool that could be effectively implemented through seven case studies (BRE, 2003). In particular, CLIP focussed on the 7Ws and the 5Cs. The 7ws are seven wastes that can never be added value: motion; waiting; defects; transport; overproduction; unnecessary inventory and inappropriate work or process. The 5Cs are the foundations for continuous improvement: clear out (separate the essential from the non-essential); configure (a place for everything and everything in its place); clean and check (assess the current condition of the environment); conformity (ensure standard is easily maintained); and custom and practice (ensure everyone follows the rules). Reported results showed improvements in production of around 15 per cent, with the highest figure being 40 per cent. None of the projects in the CLIP were highways related.

It is foreseen that some of the problems identified with implementing lean construction could be overcome through utilising the community arrangement of CM. Ballard (1998) identified that product and process design can be standardised for standard products. However, standardisation of non-standard products must be done at the planning level. This is often prevented by fragmentation between interfacing parties in the construction industry; however process mapping and trust are used within CM to achieve a cohesive and unified community, which facilitates improving systems, rather than simply defending individual interests.

Lean construction in CM

In a study by Alarcon and Diethelm (2001) of seven Chilean construction companies introducing lean practices into their organisations, the lessons learnt were outlined.

These included the importance of signals from upper management for motivation commitment of other levels of the organisation; commitment from site/office managers; early constitution of an improvement committee, in charge of implementation; and leadership to ensure success of the process. The importance of some of these characteristics is recognised as a result of the hierarchal culture in the Chilean construction industry that may not be so prevalent in the UK. However, the CMC relies on leadership and support from its “off-line” groups, which also takes on an auditing role. This puts in place an authoritative figurehead for leading and monitoring change. In addition, commitment to the CMC and its goals of industry leading performance and continuous improvement would suggest that commitment to introducing lean practices is simply fulfilment of those promises. In theory, lean construction could quite easily add value to projects undertaken by CM, and it is intended further case study research will analyse successes and failures in practice.

CONCLUSIONS

The Highways Agency has realigned its procurement strategy to take account of recommendations made in major studies in the last decade, and create a more sustainable way of doing business. It has looked to partnering and framework contracts to bring suppliers together at an early stage of the delivery process, and to maintain long-term relationship based on quality and continuous improvement. In 2002, construction management contracts were awarded in two of its areas, and the CM community was established to facilitate the ethos of partnering to deliver best value and continuous improvement. Early indications show that this form of procurement is at least as competitive as traditional procurement methods, and there is some evidence of improvement year on year. Further case study research will be undertaken to establish and demonstrate the success or otherwise of the construction management framework in highways maintenance work.

While selection of appropriate procurement methods theoretically allows realisation of best value and continuous improvement, it is suggested that it is at the operational level that potential savings are most easily recognised and recovered. Lean construction has been identified as the biggest opportunity for improving productivity at the operational level, and evidence of applying lean thinking principles from manufacturing to the construction environment suggests benefits can be achieved. Furthermore, some of the problems with implementing lean construction may be overcome through the framework of construction management, and further research will analyse and demonstrate whether these benefits can be achieved in practice.

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