BENCHMARKING - A TOOL FOR LEAN CONSTRUCTION

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Abstract
Globalisation of the economy has lead to an increased competition in what is rapidly becoming a universal market. While the manufacturing sector has been relatively quick in responding to the changing business environment, the construction industry has lagged behind. The manufacturing industry has derived great benefits from measuring its performance through critical success factors as a part of a regime of continuous improvement.

The construction industry can adopt similar practices of performance measurement and comparison to develop a culture of 'lean construction' through continuous improvement. The objective of this approach is to lower costs and increase productivity, resulting in a sustained competitive edge. This approach will involve development of metrics for performance measurement and benchmarking them with the best.

This paper looks at the elements of lean production and lean construction, as well as the current practices, issues and outcomes of performance measurement and benchmarking. Some of the key performance issues that could be targeted for improved productivity in the construction industry are highlighted along with the potential benefits that would accrue to the industry.

Keywords: lean construction, performance measurement, benchmarking

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INTRODUCTION

Recent globalisation of the economy has brought to fore the concept of a 'borderless enterprise'. This, in turn, has lead to an unprecedented intensity of competition in what has now become one big international market place. Even before this momentous change in the ways of conducting business, some manufacturers, particularly elements of the Japanese manufacturing sector, had realised the need of moving away from the traditional concepts of product engineering and productivity. Lately, others have followed. This has resulted in a tremendous growth in productivity while simultaneously enhancing the ability of the manufacturing industry to respond to changes in the business environment through increased flexibility.

During this period of rapid change, the construction industry has lagged well behind manufacturing in productivity growth. Techniques such as partnering, continuous improvement, just-in-time material delivery, improvements in ease of assembly and automation have resulted in marginal improvements in construction but have failed to provide the significant gains in productivity achieved in manufacturing. The authors estimate that the construction industry lags some 10 years behind manufacturing in the application of major related innovations. This can be attributed to three primary factors, first of all perhaps due to a fragmented rather than integrated approach, secondly due to the fact that in the past, the construction industry saw itself as being involved in a unique process with a primarily domestic base. Finally and more importantly, the construction environment is significantly more complex than manufacturing and consequently technical innovations have to be more developed before they can be successfully implemented.

However, in today's competitive environment, just as there is a need for enhanced productivity and reduced costs in manufacturing the same pressure is felt in construction.. It is essential for construction enterprises to realise that a significant improvement in productivity is needed merely to maintain market share in the face of intense competition in the global marketplace, and further efforts are required to enhance it. In the recent past there has been a growing recognition among researchers that construction is a specialised application of manufacturing in a highly complex and variable environment. This has lead to the realisation that management and technical innovations in manufacturing have direct relevance for construction. It follows then that valid comparisons can be made between construction and manufacturing industries in order to enable the former to learn from the manufacturing industry in a drive towards improving enterprise efficiency. This realisation has lead to coining of the phrase 'lean construction'.

Lean construction, derived from lean production, is a fundamental shift in the philosophy of construction practice. In discussing the potential of these work processes to construction, Barlow (1996) observes that systems have to be designed to suit both the process and product being made. He notes that many of the construction industry's activities are unlike those in the manufacturing sector. They do not involve a continuous production process resulting in uniform products, there are fewer uniform tasks and consequently processes need to be flexible. Similarly Baker (1996) cautions that lean production is suitable in cases where there is only limited variation in the volume and mix of products and tends to be most effective for relatively standardised products.

While some see the benefits of adopting this approach only in terms of achieving redefined goals, others have argued in favour of suitably adapting the elements of lean production to transform traditional construction into lean construction. The latter can be

supported in part by making use of a very powerful tool, namely, performance measurement and benchmarking.

This paper develops the thesis that, just as manufacturing has found that performance measurement is critical to continuous improvement in manufacturing, it is similarly critical in construction. As these tools are developed in construction, all parties will become more focused on performance. Objective comparisons will inform senior management about efficiency and about management team performance. In contractual relationships, objective comparison will inform parties about the performance of the other party, both up and down in the relationship. Specifically, it will enable the clients to obtain enhanced product quality and more reliable provider performance. The service providers, whether in the role of contractors, subcontractors, or designers, would be able to compare their project processes and outcomes with those of the "best", both internally between the projects and externally with other enterprises to improve their efficiency and competitiveness.

This paper discusses the following topics: (1) lean production and lean construction, (2) benchmarking for lean construction, (3) case studies and current practices of benchmarking, (4) overview of applications and obstacles in benchmarking, and (5) target areas for benchmarking in construction industry and their potential benefits.

LEAN CONSTRUCTION

Lean construction is a derivative of what Koskela (1994) described as the "new production philosophy", more commonly known as lean production. Lean production gained fame as a result of the landmark study by Womack et al (1990) which investigated the Japanese automotive industry and ascribed its success in achieving a technological and competitive edge to the concept of lean production systems. Flexibility, i.e. the ability to respond quickly to a changing environment, was described as the principal strength of such systems which, of course, relied on integration of individual elements into a whole system. This unique approach resulted in "greatly decreased cost and time with improved quality and customer service across the industry" (O'Brien 1996).

While the industrialised housing manufacturers in Japan already utilise the principles derived from their car industry, the need to adopt this new paradigm in construction practice worldwide has also been recognised. Koskela (1994) pointed out that the construction industry could utilise the generic principles, techniques and tools of lean production to great advantage and substantial improvements could be realised within a few years of such a progression. Koskela (1994) also noted that where some elements of lean construction had been adopted, success had been achieved in terms of a substantial reduction in the number of defects, compression of project duration by 10%, and reduction of accidents by 95%.

O'Brien (1996) argued that the construction industry needed to shift its focus to the underlying philosophy of lean production by recognising construction as a flow process in which construction should be seen as a hierarchical collection of value generating flows and achieve the goals of lean construction (production) - to do more with less of everything.

Womack et al (1990) have deliberated upon the topic of lean production in great detail and have provided a comprehensive discussion of the issues and options in the adoption of lean production in general. The salient features evident from their work can be categorised into processes and their immediate management and the broader

arrangements for management of the business as a whole. Both aspects play a role in the success of lean production systems.

The second management goal in the Japanese car industry, the holistic management of business appropriately tied into the production system, relies heavily on long term internal and external business relationships. While the detailed application of this practice may be different in the construction industry, the potential of the broader principle merits discussion. According to Koskela (1994), the principles, techniques and tools which are related to the processes of lean production and their management can be usefully employed by the construction industry. He classifies the prominent features of lean production in two categories, organisational and functional. These are set out in Table 1.

Table 1 The prominent features of lean production as defined by Koskela (1994).

The organisational features include:
teamwork
leadership
communication
even distribution of work
devolution of responsibilities to those adding value
customer focus
tracking and documenting causes of defects
simultaneous planning
The functional features include:
quality control
JIT production
multi-skilling
continuous improvement
simultaneous development

While differences between the nature of manufacturing and construction industry need to be clearly understood, elements of lean production could nevertheless be adapted gainfully by the construction industry (the use of 'adapted' rather than 'adopted' here being deliberate). Koskela (1994) noted that in order to implement the new philosophy of lean production in construction there is a need to "focus on measurable and actionable improvement" and "learning". Herein lies the utility of benchmarking.

BENCHMARKING AND LEAN CONSTRUCTION

Benchmarking is a term that has of late been embraced with great enthusiasm in most areas of human activity. Macneil et al in their writing on *Benchmarking and Best Practice in Australia* define benchmarking as:

> *a method for organisational improvement that involves continuous, systematic evaluation of the products, services, and processes of organisations that are recognised as representing best practices*

In other words, it is the systematic use of the objective comparison of both processes and outputs, internally and between enterprises to stimulate improvement. Those enterprises which are recognised internationally as being the most efficient being described as having best practices.

Macneil et al go further to define three categories of benchmarking:

internal comparisons between the parts of an organisation
industry or competitive comparison with similar enterprises, and
generic or process comparison where similar activities or processes are compared between enterprises in different industries.

With regard to internal benchmarking it is important to note that, besides the obvious comparisons between the parts of an organisation, performance of internal processes or transactions which result in various customer-provider relationships within an entity also need to be monitored and evaluated. This will enable identification of superior practices, which can be standardised, as well as those operations which exhibit a scope for improvement.

Womack et al (1990) demonstrated the effectiveness of performance comparison in a wide range of areas. They made comparisons between international automobile manufacturers in the areas of time performance, costs, quality and a range of general business performance factors. A summary of the scope of the comparisons can be obtained from the Table 2, which is intended to be indicative rather than comprehensive.

Table 2 The scope of the analysis of the international automotive industry by Womack et al (1990)**.**

Time
in development
in production
spent on rework
Cost
in development
Quality
defects found pre sale
defects post sale
Business Performance
market share
patents registered
automation vs productivity
quality vs productivity
spending on R & D
number of suppliers
space used in production
production flexibility
relationship indicators

It is evident from the above, that benchmarking can be used to observe and compare a wide variety of processes and practices. Carefully used it can therefore inform process improvement and consequently be used as a tool in driving the transformation of traditional construction towards lean construction.

CASE STUDIES AND CURRENT INTERNATIONAL PRACTICE

The following examples illustrate of the uses of performance measurement more generally within the manufacturing sector. They identify cases where performance measurement has been used to drive process improvement. Although most of these case studies are drawn from beyond the construction industry, their focus on individual elements show how these tools can be used in to improve performance in specific areas of the construction industry.

Xerox Corporation, USA, is considered to be the pioneer of benchmarking. Back in the late 1970s, Xerox realised that it was on the verge of a crisis when Japanese companies were marketing photocopiers cheaper than what it cost Xerox to manufacture a photocopier. However, by using benchmarking against Japanese companies as an improvement tool, Xerox managed to improve their market position. Xerox started by benchmarking manufacturing and then included other areas as well. Xerox was so successful in its efforts that it has since been using benchmarking for continuous improvement.

Since then benchmarking has been used in a wide variety of settings. Avon, a US based manufacturer of cosmetics, used internal benchmarking to improve its customer services operation. They realised that while each of their branches excelled in some areas of customer service, there was a need to develop a uniform standard of customer services to be adopted by all branches. Avon management identified the targets for improvement, separating out those which needed immediate attention. They then picked the best practices from each of the geographically dispersed branches and set it as the goal for all.

Janssen Pharmaceutica (a large drug manufacturing company also based in US) used competitive benchmarking to reduce administrative overheads. It is important to note that, despite being in a very strong competitive position, the management of Janssen adopted external benchmarking as a precautionary measure to remain in the lead, rather than falling behind. Eventually, Janssen undertook two benchmarking studies. It is quite interesting to note that, even though these studies confirmed Janssen's competitive edge, they still enabled Janssen to identify opportunities for reduction of costs in administration and marketing areas.

Cherett (1994) notes that benchmarking activity impacts upon more than 40% of European Quality Award markings and cited a Coopers and Lybrand survey indicating that 67% of the top 1000 companies listed in *The Times* were actively involved in benchmarking with a success rate of 82%. It is worth noting that benchmarking is not only practised by those enterprises which are lagging behind, but it is also used by internationally renowned successful companies as a tool for maintaining their competitive edge. Exxon Chemical, a multi-billion dollar multinational, used benchmarking to analyse how they managed their information system and whether it could be improved. Although this study was limited to practices within the chemical industry, it could also be described as process benchmarking since it focused on a particular process. As a result of this study, Exxon restructured their management of information system despite the fact that, overall, they were one of the leading enterprises in chemical industry.

IBM is another example of a large multinational corporation using benchmarking despite its established leadership in the field. The IBM facility at Rochester is responsible for development and production of mid-range systems, storage products, and cards (Eyrich 1991). It is, what is known as, a Computer-Integrated Manufacturing (CIM) site. The goal of the management of IBM Rochester was to be the leader within

IBM as well as be the best global facility. Using the Analytical Hierarchy Process (AHP), IBM Rochester were able to identify what needed to be compared and, subsequently, proceeded with their exercise of benchmarking. Although their results indicated that they were one of the best, Eyrich (1991) states that: "To be the best on a sustained basis, global competition dictates a continuous need to compare with the best. Over time, goals set and achieved from this process will enhance one's ability to achieve sustained leadership."

In view of the benefits associated with benchmarking, and the need for continuous improvement, many large enterprises have created permanent set ups for this purpose. British Telecom has introduced BT Benchmark Forum to coordinate benchmarking throughout the enterprise and provide overall guidance (Cherrett 1994). A particular aspect worth mentioning in this case is that, in addition to information from their partners, BT analysis publicly available information to compare competitive costs. BT has gained many benefits through benchmarking and continues this project with the intention of becoming a 'benchmark' (Cherrett 1994). Similarly, General Motors have also created 'Worldwide Benchmarking and Business Analysis', a group that is supporting and guiding GM's benchmarking activities (Sprow 1993).

BENCHMARKING IN AUSTRALIA

In Australia, the need to gain a competitive edge both domestically and internationally has never been greater. The changed business environment of the 1990s and intense global competition has created the need for enterprises to compare themselves with the best in the world and then overtake them. This need has been specifically recognised in the report which resulted from an Overseas Study Mission (Department of Industrial Relations and Australian Manufacturing Council 1992). A subsequent survey of the top 500 enterprises in Australia revealed that the leading organisations were well aware of the need for and benefits of benchmarking as a tool of assessing their own performance and, consequently, adopting practices that would enable them to gain a competitive edge (Macneil et al).

The survey by Macneil et al discovered that "the practice of benchmarking is widespread, has been established for several years, and is increasing". According to this survey, by 1992-93, about 41% of the top 500 enterprises were practising benchmarking while another 29% intended to do so. Benchmarking is being practised by a wide range of entities including those from manufacturing, wholesale and retail, finance and business services, mining, transport, utility, and other services sectors. It was also learned in this survey that most of the large enterprises tended to have their own benchmarking teams.

One specific example mentioned by Macneil et al is that of Aerospace Technologies of Australia Pty Ltd (ASTA). In 1989, the business figures of ASTA revealed how they lagged behind domestic and international competition and were possibly on the verge of a crisis. The management of ASTA responded by launching a program of improvement in 1990. This program comprised five initiatives including benchmarking. As a result, sales per employee rose from $35000 to $92000 within two years and all other indicators showed a great deal of improvement. ASTA attributes a great deal of this improvement to benchmarking (Macneil et al).

Another example of successful benchmarking practice in Australia is that of Sterlands Pty Ltd, which is the largest manufacturer of prefabricated wall-frames and roof-trusses for the housing industry. Within one year of implementing benchmarking, Sterlands Pty Ltd reported more than doubling of the on time deliveries, associated with significant improvements in areas such as time lost in accidents and absenteeism.

OVERVIEW OF APPLICATIONS AND OBSTACLES

In summary, when the practice of objective performance measurement and benchmarking is reviewed internationally, it can be seen to have been applied with success in a very broad range of areas. However, as cautioned by Sprow (1993), for successful benchmarking it is critical to view benchmarking as a process of improvement rather than that of exposing a company's weakness. It is also important that there exists a clear definition of a company's processes and their strategic objectives, and there is a definite plan for what is to be benchmarked and how is it to be measured. More importantly, a customer focus and understanding of customer needs are cited to be an essential requisite of any exercise in benchmarking. Nevertheless, the success of benchmarking can be gauged from the fact that some enterprises, whose market leadership position was in fact confirmed by their exercise in benchmarking, continue to practice benchmarking because, despite their overall leadership, they were able to identify areas for further improvement. Some of the key issues targeted in the case studies cited in this paper are set out in Table 3.

Table 3 Areas of benchmarking in the manufacturing sector.

overhead costs	staff turnover
managing IT systems	lost time due to accidents
productivity	sales per employee
customer satisfaction	development time
rate of innovation	defect levels
product quality	rectification costs
costs competitiveness	suggestions per employee
absenteeism	stock levels
speed	space per unit
waste	return on capital
on time delivery	sales success ratios

From Table 3 it is evident that benchmarking is not limited to end product quality, to the quality of client services or an overall bottom line performance. Rather it provides an insight into each critical element or function that will, in the end, affect the overall performance of an organisation. The identification of the critical success factors is therefore essential. In each instance where objective comparison is planned, several parameters must be met.

> *The measurement rules and protocols must be so clearly and objectively defined that an assessment made by any person attempting to measure performance would yield the same result.*
> *Any area selected for measurement must be transparently related to a desired outcome so that it informs process improvement as directly as possible*

The achievements of certain manufacturing organisation through the use of benchmarking are very impressive. Table 4 describes some of the outcomes achieved from benchmarking in known case studies within the manufacturing sector, both within Australia and abroad.

Table 4 Typical outcomes achieved in the manufacturing sector.

sales/employee/annum up 300%	customs cycle time reduced 72%
direct/indirect staff ratio up	manufacturing waste reduced by 69%
staff change down 50%	team participation increased 350%
no industrial disputes	manufacturing costs reduced by 34%
on time delivery doubled	lead time down from 6 months to 2 days
lost-time accidents down 30%	supervisory personnel reduced by 50%
absenteeism halved	cycle time down from 54 to 20 days
lead time reduced 83%	service readiness up from 73% to 91%
customer rejects reduced by 85%	optimum cycle down from 240 to 24 hrs
inventory reduced 60%	

THE POTENTIAL USE OF BENCHMARKING IN CONSTRUCTION

Construction, because of the diversity of its products and processes is one of the last industries to embrace objective performance measurement. This does not diminish the potential benefits that will be derived, however it gives some indication of the fact that there is still considerable work to be undertaken to define both the areas where the tool might be valuable and the methods of measurement.

The following case exemplifies this very well. In 1992, the late Richard Roberts, studying for a postgraduate degree tried to identify the cost of rework on 6 major construction projects in Australia. The diversity of site accounting practices between contractors and the absence of commonly accepted definitions, protocols and terminology made this exercise impossible at any level other than as a rationally substantiated estimate.

However, enterprises in the construction industry have a set of needs that this approach can address. These may relate to a number of objectives:

- driving process improvement based on internal or external comparisons of performance
- product quality improvement based on objective measurement
- assessment of performance of parties in contractual relationships, both the client and the services provider

In all cases feedback can lead to improved efficiency. The following table, Table 5 shows some of the issues that can be targeted for benchmarking within the construction industry along with the potential benefits that could be obtained as a result of the consequent improvements.

The examples are indicative of the scope of performance measurement as a tool to drive efficiency in an enterprise. Similarly, objective measurement is a useful policy tool to drive process improvement within the sector. For example in Singapore the Construction Industry Development Agency uses performance measurement in quality and in prefabrication combined with the reward of tender advantage to best practise service providers to drive industry reform within the sector. This combination of objective assessment with positive incentives is a potent policy for industry development.

Table 5 Some potential targets for performance measurement in construction.

Issues	Benefits	
Improvements within a project	Rework	Reduce waste
	Quality	Lift client satisfaction
	Safety	Lift team morale, manage risks
Comparing projects and enterprises	Rework	Reduce wasted work
	Productivity	Drive process innovation
	Product Quality	Improve client satisfaction
	Safety	Develop safety practice, manage risk
	IR	Develop IR best practice, manage risk
	Information technology	Identify and promote best use of IT
	Tendering process	Reduced tendering costs
		Increased tender success rate
Enterprise efficiency	Internal coordination	Reduce project completion time/cost
	HR management	Reduce staff turnover/absenteeism and related costs
		Team building for better participation and improved overall performance
	Overheads	Development and utility of skills for competitive advantage
	Tender efficiency	Reduce overhead costs
		Success rates, tender costs
Upward appraisal	Decisions/approval procedures	Improved performance at all levels - benefits all stakeholders
	Information Requests	Lower tendering/final cost
	Resource coordination	Greater degree of constructability
	Customer- provider chain	Improved coordination - lower costs
		Better performance of contracts
		Customer satisfaction at all levels

CONCLUSION

Experience has shown that most of the very successful companies in the world use the techniques described in this paper to improve their competitiveness. The paper shows that the application of objective measurement and benchmarking is useful at both the enterprise and the policy level. These tools provide the basis for improvements in efficiency and competitiveness and also provide an excellent basis for training.

While the variables in comparing construction projects are different, and the complexity in making comparisons is recognised, there is no doubt that with sufficient effort, valid comparisons can be made. Common elements between project activities need to be identified to form the basis of objective comparison. It is essential that every aspect of an activity that impacts on the measurement must be fully defined.

If the construction industry is to become a lean industry, the tools described in this paper are critical in the improvement process that will take it there.

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