

Project and Production Management Intersection: Life-Cycle Analysis of On-site and Off-site Construction

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Abstract

The purpose of this paper is to provide an argument for moving beyond calls for increased construction industry productivity based on the perceived differences between construction projects and manufacture production. Traditionally scholars have claimed that the lack of increased construction industry productivity is attributable to the differences between on-site work and off-site work. However, in 2011 project processes and product outcomes are essential to both. As management theories have become integrated into practice in both industries, the management of both a unique project and product-production have converged. At the same time, almost all construction today utilises both on-site and off-site processes. Therefore, the driver for increased off-site manufacture to ensure increased industry productivity must be reconsidered. One way forward would be to consider issues related to reducing the environmental impacts of construction. That is the aim of this discussion paper. Many researchers have identified difficulties with communication between on-site and off-site production. However, if the focus of productivity gains shifts to measuring environmental impact, based on a Life-Cycle Analysis (LCA), then both the tangible and intangible effects of both on-site and off-site work can be compared. Thus, over-coming identified difficulties with a common language based on LCA could enable co-operative on and off site production. This co-operation could in turn lead to increased industry productivity. The paper ends by providing a LCA focused research agenda to provide evidence for reconsidering the claim that increasing off-site manufacture will increase construction industry productivity.

Keywords: Project Management, Production Management, Lean Construction, Life-Cycle Analysis, Australia

1. Introduction

The construction industry is considered to be a project-based industry that distinguishes it from the production-based manufacturing industry. However, the reality of both industries, in 2011, is that project processes and product outcomes are integral to both. At the same time numerous scholars have outlined the differences between the focus on project or production. However, as management theories (Bresnen & Marshall, 2001) have become integrated into practice in both industries, the management of both a unique project and product-production have converged (Winch, 2006; Aurich & Barbian, 2004).

At the same time, research into construction industry productivity continues to be based on the perceived differences between construction projects and manufacture production (Horman & Kenley, 1996). One focus in past research has been lack of increased productivity due to the differences between on-site work and off-site work. These differences are often attributed to the differences between project and production practice. Simply put, the 'bits' of a building, road or tunnel can be constructed in one of two locations; on-site or off-site. However, as almost all construction today utilises both on-site and off-site processes, this simple dichotomy needs to be questioned (Zwikael & Globerson, 2006). That is the purpose of this paper.

The balance of this paper begins with a comparison of management of a project and management of production. The third section outlines communication issues for both project and production, specifically the perceived difference between on-site and off-site construction processes. Section four suggests that these differences could be alleviated by using the common language of life-cycle analysis (LCA). Section five provides a LCA focused research agenda to provide evidence for construction processes that support a sustainable built environment. These are followed by a short conclusion.

2. Management of Projects and Production

Productivity within the construction industry is hard to measure. According to Eastman and Sacks (2008) studies that compare construction industry productivity with manufacturing industry productivity do not provide plausible evidence of below average productivity. This is especially true because of the increased use of manufacturing technologies for construction projects.

Project management and production management do appear to have differences, at the same time the parameters and scope of each is not mutually exclusive. The identified differences may only be appropriate when related to a specific part of either a project or a production process (Horman & Kenley, 1996).

However, it is important to discuss some of the identified differences as the background for comparisons between on-site and off-site manufacture for construction projects. While this

paper does not intend to provide evidence for increased productivity through increased off-site manufacture in construction projects, it does intend to suggest another way of considering the issue.

The new approach that is suggested is to link project and production in sustainable construction based on life-cycle analysis (LCA). It is assumed that by changing the focus of the debate, new data can be generated which may provide a different perspective.

Table 1 Comparison of selected project and production management differences

<i>Management</i>	<i>Project</i>	<i>Production</i>
<i>time-frame</i>	<i>short-term</i>	<i>long-term</i>
<i>role</i>	<i>objective setting</i>	<i>performance attainment</i>
<i>decision-making</i>	<i>pro-active</i>	<i>re-active</i>
<i>focus</i>	<i>goal oriented</i>	<i>activity oriented</i>
	<i>problem-solving</i>	<i>process maintenance</i>
	<i>deliverable</i>	<i>Process</i>
<i>valued attribute</i>	<i>flexibility</i>	<i>Stability</i>

Table 1 provides a sample of project and production management differences identified by a variety of researchers (Winch, 2006; Zwikael & Globerson, 2006; Bryde, 2003; Horman & Kenley, 1996). Traditionally projects have been perceived to be short-term, as oppose to the long-term expectations of operations or production. Because of the limitations of time, the setting of objectives and goals is perceived as the principle management function necessary to solve a limited number of project problems. Project decision-making is thus considered to be pro-active and flexibility is a valued attribution for the project manager. Managing the project with the focus on the deliverable is well suited to many unique construction projects; one bridge, one section of freeway, one commercial office building.

The project manager's role may be seen as an integrator of the value-chain leading to the unique addition to the built environment (London & Kenley, 2001). Management of such projects (holding together traditional design, materials and structures) is increasingly predicated on intangible success factors. These include such important management tools as vision, stakeholder satisfaction and leadership skills (Nogeste & Walker, 2005). Many scholars have found that a major predictor of successful project delivery is a well integrated and flexible team. More recently integrating ICT technologies facilitates a common vision based on well-defined goals to be shared with stakeholders and project team members.

On the other hand, the operations manager is concerned with time, cost and quality to ensure optimal performance. A production manager is expected to develop and maintain stability (Horman & Kenley, 2005). Therefore the management focus is directed towards defining production activities that are repeatable and linked to continued productivity (Bryde, 2003).

Managing production within a manufacturing structure is to ensure waste is limited using repetitive and standardised processes. It is also expected that cost savings are possible through mass assembly techniques that suit a long-term business plan. Production in a controlled factory environment provides quality assurance processes. Thus continued high performance based on a variety of monitoring and controlling processes (Nadim, 2011).

Some scholars suggest that how to manage complexity and uncertainty is to be agile through operational responsiveness (Harmon & Kenley 1996). Winch (2003) argues that the focus on material flows in production is only one part of the production model that is useful for construction projects. The flow of production information is also important as this mimics a project information flow, and thus negates the dichotomy between project and production management. The growth of Lean Construction, based on production ideals (Lapinski et al., 2006) is one obvious conduit for management of construction projects.

These examples of difference and similarity between the management of projects and the management of production do not mean that gaps that researchers have identified have been rectified. For example, numerous researchers have suggested that production processes provide the solution to long-standing construction industry problems (Winch, 2006; London & Kenley, 2001). However, no solution has been found for problems related to communication systems and practices in the construction industry (Wikforss & Löfgren, 2007; Hong-Minh et al., 2001).

3. Project and Production Communication Issues

Communication systems within factories have had many years to mature through controlled and monitored formalisation and standards. The traditional 'factory' was geared towards the production of specified products, usually mass produced. Production was labour-intensive with highly formalised and standardised channels of communication. Repetitive and routinised production, processes were expected to last for the long-term (Eastman & Sacks, 2008). This steady-state meant that required changes were perceived as modifications to existing regulations and standards. However, increasing market-orientation in all industries means that more dynamic systems of communication are becoming the expected norm. Paradoxically, the model for change for production communication is based on the elements necessary for short-term projects.

Obviously, good communication channels support project management flexibility in dealing with both internal and external uncertainty (Nofera, et al., 2011). For example, the Global Financial Crisis of 2008, and the contraction of lending by world banks meant that construction projects were stalled due to the unavailability of short-term loans (Frei 2010). In this type of environment, active and effective communication channels with all stakeholders are necessary for project continuation.

It could be argued that building a flexible communication system for a construction project is an excellent example of problem-solving skills necessary for successful project management.

At the same time the growth of ICT tools and systems means that a number of construction project informal communications channels have become standardised, becoming more production-like. A standardised communication system limits communication problems created by various specialists using their own jargon. Standardised knowledge transfer based on a variety of IT languages and products ensures that temporary, but necessary feedback channels are maintained throughout the project (Wikforss & Löfgren, 2007). The convergence of project and production attributes for effective construction project communication seems natural.

Yet, communication has been identified as a major barrier to off-site manufacture utilisation in the construction industry (Blismas, 2007). From a project perspective the lack of communication between systems along the supply chain would indicate a breakdown of the flexibility needed to obtain the objective of short-term goals (Hong-Minh et al., 2001). On the other hand, the difficulty of communication between on-site construction and off-site manufacture is attributed to different types of knowledge based on specialist jargon.

One solution to the specialist jargon difficulty of communicating would be to use a common language. One common language that is currently bringing project and production management practices together is sustainability. Sustainability is the concern with the negative impact that the construction process has on the environment. In an attempt to limit this negative impact, a number of models of practice have emerged including a life-cycle analysis (LCA) (Bilec, 2006). It may be that a new approach to an old communication problem could be to link project and production processes using the language of sustainable construction based on LCA.

4. Construction Sustainability using Life-Cycle Analysis

Rapid economic growth over the last two centuries has provided a higher standard of living for many on the planet, but progress is linked to high levels of environmental degradation. The desire to separate progress from environmental degradation is the driver of sustainability of the built environment being considered by a number of construction scholars (Vanegas, 2003).

However, problems associated with changing behaviors within complex systems (Phillis et al., 2010) and long-lead times for the diffusion of new ideas (Bresnen & Marshall, 2001) provide rationales for the limited operational acceptance of sustainable construction practice. Although evidence of a limited shift could be assumed by the financial commitment from contractors, consultants and government agencies through collaborations such as the Australian Sustainable Built Environment National Research Centre (SBEnrc 2010).

At the same time one important sustainability concept appears to have gained acceptance in practice. The life-cycle framework is based on the ideas that responsibility for environmental impact for all construction processes *and* the responsibility for the life and disposal of the end-product must be addressed. Indeed a LCA is expected to be undertaken at conception of any addition to the built environment. Scholars are supporting this initiative by providing evidence for practitioners. For example, commercial building life-cycle costing (Aye et al., 2000) and

identification of intangible factors for prefabrication housing (Luo et al., 2005). A growing number of scholars from diverse fields argue that sustainability should be seen as the organizing principle for both construction projects and production. Therefore, it is possible that convergence of both types of processes can be linked by the concept of sustainability through life-cycle models.

If indeed projects and production are similar, then off-site manufacture and on-site production may also be similar. If this is the case, then the slow up-take of off-site production in Australia requires additional study in light of importance of production processes in managing and limiting waste (Horman & Kenley, 1996).

5. A Life-Cycle Analysis Research Agenda

As mentioned above the wide divide between project and production has narrowed considerably (Aurich and Barbian, 2004). Production systems are no longer geared to long-term product-lead outputs manufactured in one location. Stock-piles of identical objects have been revolutionised through JIT inventory controls and customised consumer-driven short-term design. These attributes once allocated to artisan customised products have become part of an ever-growing proportion of highly computerised global manufacturing. Indeed the location of manufacture may be different from the assembly plant. These changes in manufacturing mean that the construction industry distinction between off-site manufacture and on-site production is probably obsolete (Winch, 2006; Bresnen & Marshall, 2001).

However, major changes in belief and practice diffuse over time and in a fragmented way. Therefore, the construction industry in Australia may still have an un-realistic expectation related to both on-site and off-site production processes (Hong-Minh et al., 2001). Some construction industry stakeholders may understand that convergence is a positive driver for changing building practices based on sustainability principles. But because of the fragmented nature of knowledge diffusion, it is important to continue to undertake research to provide evidence for industry stakeholders still to be convinced.

One way forward would be to change the unit of analysis for research questions from location to process (Luo et al., 2005). This paper therefore suggests the use the life-cycle analysis (LCA) concept to frame a research agenda. Three research questions about on-site and off-site processes from a LCA perspective are suggested.

5.1 Can the LCA for on-site and off-site process of a construction project provide comparable information?

Posing this question may provide a methodology for construction industry use. The three initial steps of a project LCA are: an inventory of energy use (inputs and outputs), evaluation of the environmental impacts, and taking these into account for decision-making (Junnila et al., 2006).

Currently researchers around the world are working to create measurement tools and methodologies for LCAs including those that can be used by the construction industry.

5.2 Will the results of a LCA for a process that can be used both on-site and off-site provide evidence of intangible factors needed for good-decision making?

A more sophisticated version of the LCA takes into account materials as well as energy use. In addition, the consideration of end-of-life issues adds a second meaning to life-cycle, one that continues beyond the project. Thus the construction process (including building materials) need to be analysed as well as energy impacts for the use, maintenance and disposal of the finished product: building, road or residence. Clearly, identification of the intangible factors for off-site production has an added layer of life-cycle that needs to be addressed to provide optimal management tools for construction projects (Bilec et al., 2006).

5.3 Is it possible for the LCA to compare both the up-stream and down-stream factors for a specific process that could be produced on-site or off-site?

The growth of LCA focusing on non-financial factors of environmental impact continues to grow. The complexity of construction process related to the intangible relationships of construction projects means that networks of suppliers of machinery, materials and knowledge need to be included in any construction project LCA. Categories for analysis must start with early development and input into tenders. Complex comparison of on-site and off-site fabrication must include a wide variety of energy inputs and outputs. For example, fleet manufacture as well as processes for primary materials, including location of origin, distance to first processing, types of processing and transportation to construction sites. If these up-stream and down-stream relationships are mapped, a more accurate accounting of total environmental impact is expected, thus making any comparison between on-site and off-site more equitable (Chang & Kendall, 2011).

6. Conclusion

The call for increased productivity in the construction industry is often based on the view that the individual and unique projects that create the built environment are an inefficient use of resources. An often claimed solution for increasing productivity is the increase use of off-site manufacture. Globally construction of housing units have utilised this factory method of production, to a larger or lesser extent. However, commercial and infrastructure construction lags behind. With global concerns predicated on a life-cycle responsibility model, more than ever issues of construction industry productivity through consideration of environmental impact

are required. The research agenda set out in this paper may pave the way for a re-assessment of the issue.

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