THE ARCHITECTURAL TECHNOLOGIST'S ROLE IN LINKING LEAN DESIGN WITH LEAN CONSTRUCTION

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ABSTRACT

From a UK perspective the purpose of lean design is to improve the 'manufacturability' of a product; the purpose of lean construction is to improve the flow of information, materials and people in the production process. Both lean design and lean construction are concerned with generating unique value for the customer, thus they are part of the same process; each is highly interdependent on the other. Design (both conceptual and detail) cannot be considered as separate from the construction process: it is a team activity encompassing the input of many specialists, which need to be co-ordinated. Key to this is an understanding of design and production processes. Architectural technologists, because of their education and training, are uniquely positioned to materialise design intent as a value adding process. The argument developed in this paper places the role of the architectural technologist equivalent to, for example, the production engineer in manufacturing industry, whose key function is to manage the input of various contributors to produce a viable product. The role of the technologist as an integrator and enabler of a quality product within a whole life framework is, therefore, crucial for realising value and for providing the links between design, construction and facilities management.

KEY WORDS

Architectural technologist; Constructive links; Detail design; Flows; Lean approach;

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INTRODUCTION

As a result of a desire by central government to greatly improve the quality of service, quality of product and value for money delivered by the construction industry, all parties to construction have been obliged to look at processes by which these goals can be achieved. In the UK, for the most part, the design and construction of buildings has traditionally been founded on an activity basis, with transactional contracts or assignments defining the objectives of the various participants. This has resulted in a fragmented approach to building procurement which, because of the separation of the activities that make up the process, has caused opportunities for costs and errors to multiply while at the same time also limiting the opportunities to eliminate waste.

Changes to procurement processes, construction materials, construction techniques and more extensive service installations have made the construction process more complex. This has resulted in a growing divergence in core skills between design and construction resulting in different education patterns and philosophies; which is in marked contrast to repeated calls for greater integration and collaboration. The trend over the past twenty years or so has seen architects move more toward design (abrogating responsibility for detailing and management to others) and contractors move more toward management (with aspects of assembly sub-contracted to specialists). This has resulted in a widening gulf between design and production activities, with an urgent need for someone to bridge these culturally divergent worlds. In this paper we argue that it is the architectural technologist's role to bridge this knowledge gap and to function at the interface between design and construction; a role identified over twenty years ago by SAAT and termed the 'constructive link' (SAAT, 1984). It is the materialisation of the design at the detailing stage that affects the functionality, constructability, economic viability and quality of the constructed works. Materialisation is affected by upstream activities in the design phase and directly affects the efficiency of the downstream production activities.

LEAN DESIGN AND LEAN CONSTRUCTION

Through such recent UK initiatives as the reports by Latham (1994), the Egan (1998, 2002) and the adoption by central government of the Private Finance Initiative (PFI), processes once predominantly seen in manufacturing industries are now becoming more common in the UK construction sector. Principal among these is the philosophy of lean manufacturing (Womack et al., 1991; Womack and Jones, 1996) and its application to design and construction processes (e.g. Alarcon, 1997). A growing number of contractors in the UK have implemented a variety of so called Lean Construction tools and methods and some are now being supported by the adoption of lean principles by consultant engineers and designers. There are, however, some differences in the growing body of literature about the meaning of the terms Lean Design and Lean Construction, with lean design being poorly defined at present. These are explained from a UK perspective:

LEAN DESIGN

The purpose of Lean Design is to improve the 'manufacturability' of a product through attention to information coordination and flows at the outset of the project, and the development of 'design for production' solutions to technological, functional and operational requirements. It is here in the upstream phases that value is added and subsequently embedded in the production information. Fundamental to the lean design approach is the design of appropriate communication structures before any design work commences. As a management process, it may have the following characteristics:

- Understanding the value streams by which value is delivered
- Identifying value from the customer's point of view
- Achieving synchronous flow within work processes as waste is removed
- Achieving pull so that no information is delivered until it is needed
- Perfection – recognizing that improvement needs to be constantly pursued.

As a technological process, Lean Design may have the following characteristics:

- modularity
- platform derivative design
- ease of assembly
- rationalisation of components
- reduction of component part counts
- reduction of manufacturing times
- built–in quality and reliability
- reduced complexity
- reduction in the number of production operations.

LEAN CONSTRUCTION

The purpose of Lean Construction is to improve the flow of information and materials in the production process, eliminating waste in order to produce unique value for the customer. It has the following characteristics:

- the project is structured and managed as a value generating process
- downstream stakeholders are involved in front end planning and design through cross functional teams

- project control has the job of execution as opposed to reliance on after-the-fact variance detection
- optimisation efforts are focused on making work flow reliable as opposed to improving productivity
- pull techniques are used to govern the flow of materials and information through networks of co-operating specialists
- capacity and inventory buffers are used to absorb variability
- feedback loops are incorporated at every level, dedicated to rapid system adjustment; i.e., learning.

PART OF THE SAME PROCESS

Lean Design and Lean Construction are part of the same process; each is highly interdependent on the other. Design (both conceptual and detail) cannot be considered as separate activities from the construction process: it is a team activity encompassing the input of many specialists, which need to be co-ordinated effectively if client values are to be transformed into a high quality, functional and serviceable building. Key to this is a thorough understanding of design and production processes and recognition of the importance of architectural detailing. Architectural technologists, because of their education and training, are uniquely positioned to materialise design intent as a value adding process. Positioned between conceptual design and production the architectural technologist forms a creative and constructive link in the value chain (Emmitt, 2002). The argument developed in this paper places the role of the architectural technologist equivalent to, for example, the production engineer in manufacturing industry, whose key function is to manage the input of various contributors to produce a viable product.

LEAN DESIGN AND CONSTRUCTION AS A PRODUCTION PROCESS

According to Koskela (1998), the main principles of lean production include the following:

- An increase in the efficiency of value-added activities as a result of improvement in production technology and production skills
- A reduction in the share of non-added value activities, leading to simplification, reduction of variability and increased flexibility
- Achievement of product specifications, thus improving customer value
- A comprehensive and integrated approach to improvement; action orientated to implement lean production principles in design, control and production.

In the UK there has been, and continues to be, considerable political pressure and associated efforts within the sector to move construction away from short-term transactional-orientated construction processes towards processes which can lead to (among other things) the implementation of lean production principles. This is being achieved through better co-ordination of the constituent parts of the construction process – for example, briefing, architectural design, structural design, services design, specialist sub-contractors and main contractors – as an integrated approach.

Corbett et al (1993) notes the most important aspect of the product design development process is concurrent design of the production process. In other words, an integrated design and production process is developed that aims to remove waste, increase quality, achieve cost certainty and predict future performance. This system contrasts to the traditional construction process that is based on serial design development, where the design phase tends to reach its end before the production solution is considered. Opportunities to capture the expertise of the construction team and develop cost-effective and innovative solutions are lost because design review becomes more complex and costly and resistance to change becomes greater as time passes (see Figure 1). Research has shown that 80% of construction costs are fixed in the first 20% of the design process; therefore, it is critical that this phase of the value process is thoroughly resolved before work proceeds, thus helping to reduce uncertainty and waste further downstream as the abstract is transformed into the tangible.

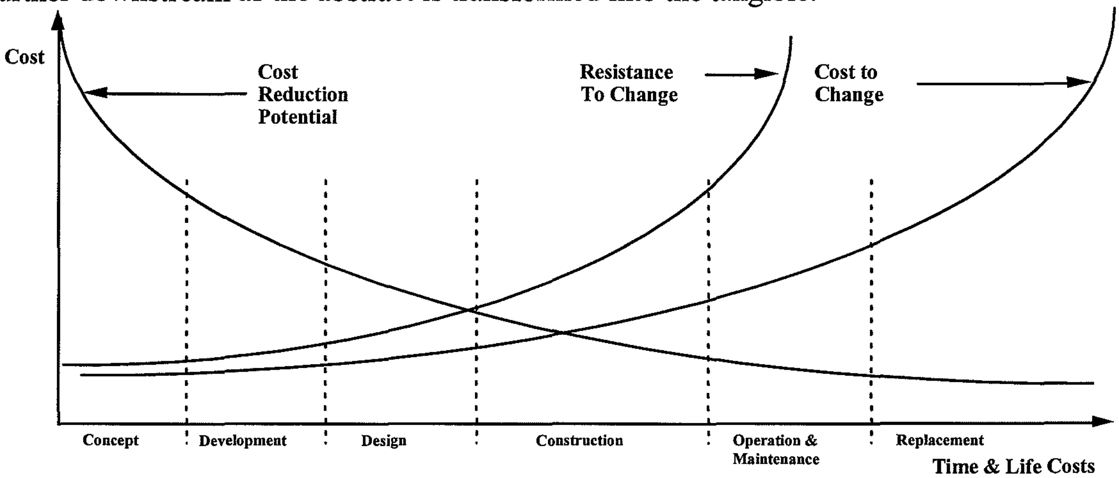

Figure 1. Implications of cost-versus time (Hayles & Simister, 2000)

Melhado (1994) defines building design as "an activity or service that is an integral part of the building construction process, dealing with development, organisation, documentation and transmission of information on the specified physical and technological characteristics that must be considered in the construction phase of a particular project." The design process "must be interpreted not only as an architectural or engineering problem, since it is a multifunctional work that involves from marketing and costs analysis to technological choices and production process specifications" (Melhado, 1995).

Study of the design/construction interface has shown that it is generally in the execution phase that defects inherent in the design process become apparent. Alarćon and Madones (1998) note that the principal problems arise in:

- poor design quality
- lack of design standards
- lack of constructability.

Symptomatic of these problems was both a lack of appropriate information and incorrect or incomplete information. The root of this problem was founded in the continuous change and modification of the design, coupled with poor communication and co-ordination of activities between the team members. Analysis of information collected in Alarćon and Madones's study showed that the design process was chaotic and did not allow the construction professionals a complete exposure to the completed design. This prevented the necessary interaction among the various specialities that are part of the process.

A new design management methodology is required to address these difficulties. Melhado (1998) suggests that such a methodology might have the following characteristics:

- The design and the construction process must be equally considered at the very early stages of the design process (an opportunity for significant value-adding)
- Systematic post-occupancy evaluation must be implemented as part of a feedback information system aimed at designers to prevent some possible repetition of technological specification and detailing errors
- Building design, as a multi-disciplinary activity, needs a multi-disciplinary team of several specialised designers and consultants working together from the very early stages of the design process
- Design co-ordination needs to have pre-established parameters and criteria in order to orient, analyse and criticise design solutions properly
- Design management involves not only design review procedures, which are related to the real estate developing and construction companies, but also a well-supervised quality control procedure within the contracted design firm
- Supply, work, training technological development, design and construction processes must be oriented by the same statements of an organisational programme that a company is developing.

The above methodology requires an integrated approach to design management such that the expertise of all stakeholders is captured early in the design process. Hill (2000) notes that that an integrated construction process has the objectives of effective cost management and improved functionality leading to better value construction projects. Alarćon and Madones (1998) suggest that design process can be improved by adopting the following four different actions:

- **Supervision** of the design process. A construction company must participate in the design process, in order to avoid the problems related to lack of construction knowledge of the designers, providing its experience in design solutions
- **Co-ordination** of the different specialities through a logical sequence of information transfer, avoiding incorrect assumptions, and giving a priority level for changes in order to avoid lack of co-ordination and to improve the design compatibility
- **Standardisation** of design information, to avoid omissions, errors and continuous changes, which affect the normal development of projects
- **Control** of the flow of information, verifying that the requirements of previous processes are fulfilled in order to avoid design defects arriving on the construction site.

Achieving the desired outcome of these actions can be realised by adopting a concurrent engineering approach to design management, such as that proposed by Melhado (1998) as illustrated in Figure 2 below.

Central to the concept of 'design for production' is the introduction of a new type of design consultant who deals with the development and detailing from a 'design for production' perspective. This process is focussed on the 'concurrent design' of the parts of the building that are critical, such as, formwork, partition walls, floor detailing, external cladding, waterproofing etc. The role of the consultant needs to be filled by a person or organisation whose experience is cross-functional, that is, while not necessarily being an expert in each of the individual fields, has a knowledge and understanding of the implications and necessity of design and production decisions. This position would, with some additional training and specialisation (perhaps through postgraduate education and training programmes), suit the Architectural Technologist (and Architectural Engineer) perfectly – schooled as s/he is in the art of bridging the gulf between the culturally differing worlds of the conceptual and the practical and having:

- Knowledge and understanding of the design process and appreciation of the value of design; contractual issues and professional obligations
- The ability to translate design intent into construction, maximising efficiency and satisfaction (the ability to materialise)
- Knowledge of the physical and performance factors of building materials and associated technologies
- The ability to work fluently within a multi-disciplinary design team.

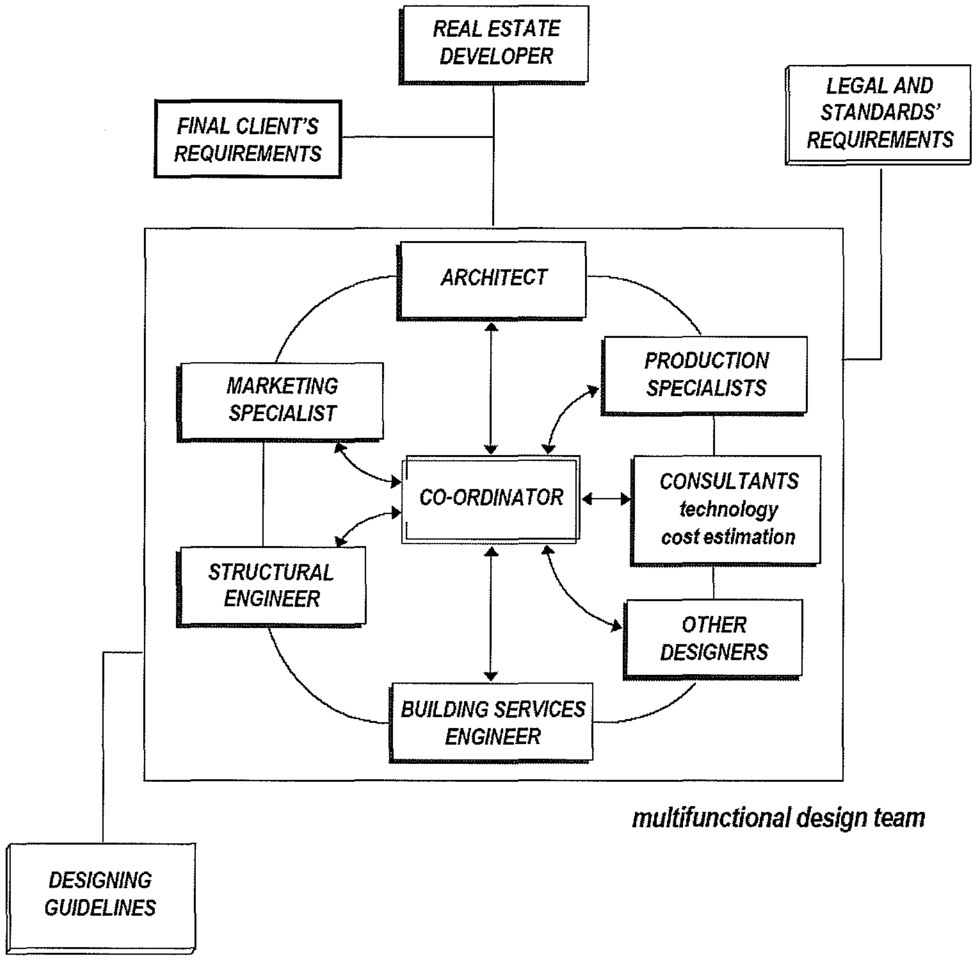

Figure 2: Proposal for a multi-functional 'design for production' team (Melhado 1994)

The consultant is effectively acting as an enabler and facilitator to ensure that the goals of the project brief are achieved as innovatively and cost-effectively as possible, i.e. they are operating as a constructive link between design and production. The job is one of adviser, inquisitor, tactician, adjudicator and diplomat and individuals working within this role should, as a minimum requirement, possess some of the following characteristics while maintaining professional integrity and impartiality at all times. He or she should be:

- Calm, self-confident and controlled
- Individualistic, serious minded and unorthodox (intuitive and deductive)
- Enthusiastic, curious, communicative
- Socially orientated

- Sober and prudent.

THE ARCHITECTURAL TECHNOLOGIST IN A 'LEAN' ENVIRONMENT

Emmitt (2003) has looked at the education of architectural technologists and has argued that focusing on the principles of architectural detailing can help students to develop the necessary skills to be able to approach detailing from first principles, grounded in environmental ideals and a lean philosophy (see also Emmitt et al, 2004). The same author has also argued that the technologist is a 'timely innovation' given the changes occurring within construction (Emmitt, 2001). Some background to the growth of the discipline and the education of technologists helps to illustrate the potential.

THE GROWTH OF THE AT DISCIPLINE

The Society of Architectural and Associated Technicians (SAAT) was formed in response to an identified requirement for a body representing the interests of technicians within the construction industry, primarily architectural technicians working in support of architects (RIBA 1962). A SAAT report in 1984 (SAAT, 1984) identified the architectural technician as the role within the construction industry most likely to solve the industry's problems of the day, including:

- A demand for higher standards and therefore increased productivity
- The need for industry to absorb and adapt to the increasing rate of change of technology
- Economic instability forcing defensive and inefficient techniques on buildings
- Increased participation by society in decisions made on its behalf.

The SAAT report (SAAT, 1984) evidenced the need for a professional to take charge of the technology of the design and construction process in order to apply scientific and other systematic knowledge to the solution of practical problems such as those outlined above.

In 1994 SAAT changed to British Institute of Architectural Technologists; all members being referred to as architectural technologists in recognition of the progress made by its members in establishing the new professional discipline of architectural technology and maintaining proper standards of competence. Honours degrees in Architectural Technology began emerging in recognition of the requirement for the high level of knowledge skills required to fulfil such a complex role. To date 26 such degree courses have been accredited by BIAT, underpinned by the Quality Assurance Agency (QAA) Subject Benchmark Statement for Architectural Technology in 2000.

In 2002 BIAT introduced Technician membership, bringing some of the aims and ethos' of the original Society full circle. Introduction was in recognition of the requirement to acknowledge and differentiate between the high level skills of the technologist and those of a technician. BIAT has therefore positioned itself as the provider and protector of technical excellence in design and construction and its membership as professionals recognised as being able to supply technical design solutions. The problems within the construction industry are still apparent and, as argued in this paper, the architectural technologist is best placed to deliver solutions in terms of lean design and construction working, on integrated projects as part of an integrated team. As a relatively new role in construction the architectural technologists are well placed to adopt management innovations such as lean thinking and apply such approaches to the benefit of all actors.

EDUCATION AND COMPETENCE OF AN ARCHITECTURAL TECHNOLOGIST

Initial education is normally an Honours degree in Architectural Technology followed by industrial experience and a professional interview. The undergraduate programmes are built around the following areas:

Developing the architectural project
1. Identify, assess and challenge client requirements and user factors
2. Select and evaluate survey requirements, technical information and development factors
3. Select and agree procurement procedures, forms of contract and design team
4. Assess and advise on regulatory control and consent requirements and legal constraints

Architectural design management
5. Develop briefs and design programmes and test design solutions
6. Justify and advise on the selection of project designs
7. Recommend and advise on the selection of detailed project designs
8. Integrate, control and evaluate design documentation
9. Specify and define technical and performance requirements

Contract management
10. Procure and evaluate estimates, bids and tenders and agree contracts
11. Control contract quality, progress and costs

Post construction
12. Evaluate feedback, recommend improvements and specify maintenance information and guidance

Professional practice
13. Manage and contribute to meetings
14. Enhance working relationships and operate in a professional manner
15. Undertake structured personal development

Successful completion of these elements confers Full Membership and the MBIAT designation. BIAT's requirements are linked to its competence standards for Full Membership. Competence is maintained through an obligatory requirement to undertake a minimum of 35 hours continuing professional development (CPD) per year, as laid down in BIAT's Code of Conduct.

KEY CHARACTERISTICS OF THE ROLE IN RELATION TO 'LEAN'

BIAT define an architectural technologist as: 'The Architectural Technologist will be able to analyse, synthesise and evaluate design factors in order to produce design solutions which will satisfy performance, production and procurement criteria. This will be achieved through the design, selection and specification of material, components and assembly and the management, coordination, communication, presentation and monitoring of solutions which perform to the agreed brief and standards in terms of time, cost and quality.' Key characteristics of this integrating role could be:

- Defining the content of the main design activities, through the discussion and agreement of value parameters and associated performance requirements grounded in a lean paradigm
- Discussion and agreement by all parties to the main outputs required for each activity to achieve lean design and construction
- Implementing the underlying frameworks and tools necessary for supporting such activities (e.g., JIT/TQM)
- Understanding the processes necessary to meet the needs of lean construction (with design having priority over processes and operations as it fundamentally influences both)
- Recognising and managing the conflicts and mutual inter-dependency between design as a creative process and design as a management process
- Analysis and implementation of technical solutions to meet the project parameters using a lean approach to detailing the design
- Having an understanding of the effects of choices in design, materials, components and assemblies on capital, constructability, operational and maintenance costs; i.e., an appreciation of 'whole life performance', thus helping to link design, construction and facilities/asset management.

BIAT'S ROLE

BIAT's primary role as an organisation is as protector and promoter of technical, educational and professional standards within architectural technology. Within this role BIAT endeavours to instil a culture of innovation in its membership in order to enable delivery of innovative solutions. While innovation traditionally refers to products, BIAT realises the critical nature of process innovation and that the two elements in combination are required to facilitate lean design and integrated construction, placing architectural technologists at the heart of the integrated team.

CONCLUDING THOUGHTS

The role of the technologist as an integrator and enabler of a quality product within a whole life framework is crucial for realising value and for providing the links between design, construction and facilities management. This has been demonstrated by the development of the discipline alongside arguments put forward by, for example Melhado for a design professional at the heart of an integrated team. As a creative and constructive member of the value chain the architectural technologist, at least in the UK, may be central to the realisation of the lean philosophy through the act of creative detailing and professional management of the design/production interface. BIAT has a role in both promoting the lean philosophy and helping to create greater cooperation/collaboration between the designers (RIBA) and the constructors (CIOB).

The architectural technology profession is maturing and there appears to be a need for additional guidance/literature and more research into the impact of the technologist in a leaner and greener construction sector. For example, what is the extent of lean thinking within the construction 'team'?, what are the opportunities and barriers to the uptake of lean thinking? How does the lean approach manifest in the architectural detail? And how does this colour the serviceability and maintenance of the constructed works over a long timeframe? These questions are fundamental to the lean debate and BIAT has recently commissioned research into (1) the teaching of design skills within undergraduate degree programmes in Architectural Technology and (2) the development of an integrated team philosophy within the undergraduate teaching programmes. Both research programmes will be investigating how innovative thought is encouraged and harnessed and form part of a BIAT initiative to encourage and stimulate research under the umbrella of architectural technology. The application of lean principles in education and their transfer to practice will be one of many factors tackled in the research.

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