THE MULTIPLE ROLES OF SPECIFICATIONS IN LEAN CONSTRUCTION

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ABSTRACT

The primary goal of Lean Production is to avoid the wastage of time, money and other resources. In the construction setting, a lot of wastages are attributed to delays, rework and the subsequent non-productive efforts expended in resolving disputes arising from such inefficiencies. Deficient specifications have been implicated in many waste scenarios. Despite that, little research has been conducted to examine the deficiencies of specifications. In this paper, the causes of deficient specifications are firstly examined under a postulated framework of issues that can be reasonably expected to be addressed by specifications – embracing formatting, technical, people management, legal and communication issues. Secondly, this paper aims at exploring the potential roles of specifications in the context of some of these issues, in elevating construction performance levels through a lean construction based strategy.

KEY WORDS

Lean Production, Specifications, Deficiencies, Improvements,

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THE CONVERSION PROCESS AND LEAN CONSTRUCTION

Construction can be viewed as a combination of conversion processes and flow processes. During the conversion process, various inputs are converted into outputs with added value. The flow process, however, adds no value but generates wastes. These wastes include such inefficiencies as waiting time, longer routings of resource flow paths, rework, stoppages due to accidents, etc

Recent reviews of the Construction Industry in different parts of the world unequivocally suggest the need to reduce wastage to improve productivity. For example, the "Egan" Report in the UK (1998), the "Construction 21" Report in Singapore (BCA, 1999) and the Report of the Construction Review Committee in Hong Kong (Tang, et al, 2001) all point in this direction. These recommendations fit in well with the primary goals of Lean Production, which are to reduce wastage in an attempt to improve productivity (Melles, 1997). One facet of wastage in the Construction Industry is the collective efforts spent on producing un-useful or unusable project information, which adds to the flow process. Every project has its specifications in one form or the other and the purpose of specifications is to inform the contractor what the client wants. Yet, do the specifications fulfill their roles as setting out the quality requirements of clients? As Koskela (1992) pointed out after reviewing an extensive body of literature pertaining to quality problems, improvements have to be made in the mechanisms by which specifications are defined for each conversion activity.

This paper aims to unveil specific problems arising from specifications (e.g., in identifying the relevant "fat") and to focus attention on ways of addressing these problems through the adoption of Lean Production strategy, thereby reducing waste and improving productivity.

THE INTENDED ROLES AND SHORTFALLS OF SPECIFICATIONS

In the Construction Industry, the design team relies on the specifications to communicate to the contractors the required procedures and quality standards of building and civil engineering projects. Specifications should complement drawings in setting out what is required to be built without ambiguities. They also serve as important components of the contract documentation for controlling works carried out on site. Acceptance of completed works is dependent upon whether the specification requirements are satisfactorily met.

Given the multiple roles of specifications in the construction process, recent experiences, observations and relevant literature indicate that some of these roles are not fulfilled as envisaged. A research study was therefore launched to explore these observations further. Initial analysis led to the identification and categorisation of perceived deficiencies of specifications under a framework of five issue groups, namely Communication Issues, Formatting Issues, Technical Issues, Legal Issues and People Management Issues (as shown in Fig.1). The identification of the relevant issues as well as potential improvements are explored on the basis of Lean Production/Construction strategies.

COMMUNICATION DEFICIENCIES

LACK OF CONSISTENCY AMONGST DOCUMENTS

ASCE (1979) conducted an extensive survey on specification drafting and usage in the 1970s. The results confirmed a high incidence of lack of consistency and co-ordination in preparing drawings and specifications. This view has been echoed even recently by many practitioners in the Construction Industry worldwide (Daoud 1997).

LANGUAGE PROBLEM

In terms of the style of language being used in drafting specifications, there was concern on the over-use of technical jargons. Wyatt (1997) argued that such deficiency would render the specifications an ineffective means of communication. The lengthy sentence structure also reduces readability.

DIFFICULTY IN SEARCHING FOR INFORMATION

Apart from being part of the tender documents, specifications should be used for material procurement, quality assurance, completion checklists as well as for forming the maintenance manual. Traditional specifications, however, come in the form of printed booklets, which are too bulky to be carried by the supervisors and inadaptable for different uses. The sections are mostly arranged in trade order, making cross-referencing and searching difficult (especially when more than one volume of booklet is involved). Repetitions and inconsistency within the same document are not uncommon. For example, commonly used materials such as cement, aluminium and steel are described in different sections with varying levels of details.

FORMATTING DEFICIENCIES

GENERAL Vs PARTICULAR SPECIFICATION

In an attempt to avoid drafting bespoke specifications for similar projects, many designers differentiate generally applicable items from project-specific items by creating a General Specification for all projects of a similar nature and Particular Specifications for individual projects. The General Specification contains standardised material and workmanship clauses applicable to a range of projects, although it may not be so for all projects. Despite providing a more rationalised basis, some consultants abuse the usage of standard specifications by indiscriminately relying on them for projects outside the applicable range. That prompts the advocates of standard specifications (for example, Birch, 1983) to ask a thought-provoking question: “How standard should the specifications be?”

PROPRIETARY PRODUCTS Vs GENERIC PROPERTIES

Some consultants specify specific products rather than give generic descriptions of desirable properties. Ibbs (1985) looked into the problem areas of this practice in the US and attempted to quantify the seriousness of disputes arising therefrom. Using statistical inference techniques, he concluded that proprietary ("brand name or equal") specifications led to frequent contract disputes. The reason was that such specifications opened the door for a bidder to submit "equal" substitutes, which might not meet the client's intent.

PERFORMANCE Vs PRESCRIPTIVE SPECIFICATIONS

The recent proliferation of specialist works has seen an increasing use of performance-based specifications replacing the mainstream "prescriptive" specifications, which are characterised by detailed descriptions of material and workmanship requirements. In order to give flexibility and encourage innovations in the use of materials, systems and methods, performance specifications state the required end-results and leave the contractors to come up with means to achieve those results.

Yet, performance specifications are not without problems. Hartman (1997) quoted an attorney as saying that "an unsophisticated owner reading a performance specification thinks of a Mercedes-Benz, while the contractor sees a Volkswagen" He brought forth the question of practicality and the difficult situation where no objective criteria are available for testing.

TECHNICAL DEFICIENCIES

FITNESS FOR PURPOSE

Specification writers are sometimes not aware of the intended purpose of what they are specifying. In a study on the variability of specifications in speculative office design, Cook (1998) highlights the unnecessarily high standard being specified for UK speculative offices when compared with similar building types in several other developed countries. This study has brought to light the disparity in specification levels between buildings of the same purpose group.

OVER-SPECIFYING

A problem related to fitness-for-purpose is over-specifying. In the CIOB (HK)'s letter addressed to the Construction Industry Review Committee in Hong Kong, one of the views expressed was that "It is a common phenomenon to see many project specifications being over-specified rather than under-specified." (Li, 2000) Whilst this may be justified by designers due to the variability of workmanship standards being achieved on site (given the fact that construction operations are still mostly site based), there can be potential cost and time savings from a lean construction perspective if specifications are pitched at the right level to suit the intended purpose and sufficient monitoring is effected to achieve the desired results.

USE OF STANDARDS

The ASCE (1979) survey also highlighted that many specification writers are unfamiliar with the tests and standards they specified. As a result, it is not uncommon to find irrelevant or obsolete standards in the specifications. The multiplicity of standards also puzzles specification writers. Usually, specification writers prefer to use standard methods of testing and material standards issued by recognized authorities in their countries of origin. Local material suppliers find it difficult to demonstrate that their products are compatible with these foreign standards and costly imported materials are commonly used because of this reason (Daoud 1997). If compatibility of local materials can be established by the listing of essential product properties in the specifications, time and cost can be saved.

CONSTRUCTABILITY AND MAINTAINABILITY ISSUES

O'Connor et al (1991) reported on studies indicating the heavy price that owners and designers paid for poor specifications. They questioned the "Constructability" (defined as a measure of the ease or expediency with which a facility can be constructed) of specifications for highway construction in particular. Also, whilst much focus is being put on initial construction, the long-term life cycle performance of built facilities cannot be ignored. Furthermore, few specifications give sufficient considerations on the "Maintainability" of buildings. For example, in a condominium block of flats, how are the external faces of side-hung windows going to be cleaned? What quantities of each type of tiles should be provided to the client as spares for replacement? These facets should be spelt out in specifications to provide guidelines throughout the building life cycle.

VERIFICATION OF COMPLIANCE

Quite often, specifications contain parameters which are difficult to verify on site. Testing of items such as rebars and fire-resistant doors can only be carried out by accredited laboratories (i.e., off-site). Until recently[4], it was difficult to have an objective test on the as-built watertightness of windows and facades. This type of problem arises more on performance specifications in that an objective on-site measurement may not have been developed to verify the achievement of performance criteria with reasonable cost and expediency.

LEGAL DEFICIENCIES

CLAIMS FOR TIME EXTENSION AND ADDITIONAL COSTS

Research carried out by Kumaraswamy (1997) and Yogeswaran (1998) have identified that ambiguities within and between contract documents (including specifications) give rise to claims for extension of time and loss and expenses. Many of these claims may be justifiable if time and cost have been spent by the Contractor in waiting for clarification and carrying

[4] A watertightness field test has been successfully developed in Singapore under the Innovation Development Scheme. Details available at BCA website (*http://www.bca.gov.sg*) under the CONQUAS 21 section.

out abortive works. Apart from the sheer increase in construction costs and loss in revenues to clients, such claims waste the energy of all parties concerned as they would have to settle the disputes.

IMPOSSIBILITY CLAIMS

A number of construction contracts have recently come to a halt or proceeded to arbitration or litigation when the contractors allege that their works have been made impossible at the outset by the specifications. Examples include the Strategic Sewage Disposal Scheme and the Tsing Ma Bridge in Hong Kong. Mak (1998) looked into recent legal developments on claims due to impossibility and the frustration of contracts. The landmark case of *Turriff (1994)*[5] highlights the "physical impossibility" of achieving specified tolerances. Other cited cases[6] seem to point to "commercial impossibility" as the benchmark in this area.

PEOPLE MANAGEMENT ISSUES

FAILURE TO COMPLY

Specifications are written in highly technical language and this relies heavily on the supervisors to digest and pass on the information to the working level on site. Yet, some site operatives have a tendency to follow trade practice rather than specific workmanship instructions given by their supervisors. Unskilled workers are ignorant of proper work procedures. Hence, site management personnel have to bridge the gap by proper briefing and constant supervision. As far as materials are concerned, management efforts should concentrate on procuring the specified materials, storing and using them in the specified manner. Failure to comply or willful deviation leads to poor quality work.

FAILURE TO ENFORCE COMPLIANCE

Both the contractor's and the consultant's site supervisory staff have a common duty to ensure compliance with the specifications. If, for any reason (including corruption), this enforcement is slackened or compromised, even a perfectly written specification cannot serve its purpose.

LEAN PRODUCTION-BASED IMPROVEMENTS

The foregoing list of persisting drawbacks or deficient areas in specifications corroborates the conclusion arrived at in the ASCE survey in 1979 that "all is not well in this area of civil engineering endeavor". It can also be said that little has been done even in more recent years to bring about the much needed improvements in this important contributor to the construction process. Yet, there have been paradigm shifts in the manufacturing industry that have led to a new production philosophy as manifested in "Lean Production".

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[5] Turriff vs Welsh National Water Board [1994] CLYB122

[6] Moss vs Smith [1850] 9 CB 94 and Tito vs Waddell [1977] 3 All ER 129

Whilst Lean Production focuses on reducing wastes or the share of non value-adding activities, there are several principles that enable this to be done. Koskela (1997) summarises the principles as follows:-

1. Increase output value through systematic consideration of customer requirements;
2. Reduce variability;
3. Reduce cycle times;
4. Simplify by minimizing the number of steps, parts and linkages;
5. Increase output flexibility;
6. Increase process transparency;
7. Build continuous improvement into the process;
8. Balance flow improvement with conversion improvement;
9. Benchmark

Re-visiting the previously discussed drawbacks of construction specifications, several of the above principles can be applied to address the identified issues as described in the following sub-sections:-

CLARIFYING CUSTOMER REQUIREMENTS

The issues of fitness-for-purpose should be tackled through an explicit client briefing process, during which the client's requirements are made known to the design team in no uncertain terms. Joint tours or visits by the client and the design team to similar completed projects can be a useful starting point for the parties to visualise and compare the expected quality levels. This process will help to clarify uncertainties that may exist in written statements within the client's design brief. Yet, the specification writer must not adopt the mind-set of a mere "copycat". For a better design to evolve, one must be proactive and maintain an open mind to innovation. This applies to both the client and the design team.

REDUCING VARIABILITY IN CONSTRUCTION QUALITY

The issue of over-specifying due to variability of workmanship can be tackled by evaluating contractors' performance on a long-term basis to identify suitable contractors for the project in question. By short-listing a small number of contractors and working with them for a longer period (through partnering or strategic alliances), the specification writer can gauge the standards that can be achieved with higher accuracy, thereby minimising the need to over-specify in order to create a "buffer" quality safeguard.

Project partnering can by implemented by bringing all key parties together at an earlier stage and introducing an appropriate risk/reward sharing mechanism. Clarifications of uncertainties should be done at the outset of the project rather than during the progress of the work. Records of such clarifications should be kept by the design team to form a source of feedback for improving future editions of specifications.

REDUCING CYCLE TIME

Although the link between production cycle time and specifications is not obvious, a clear and unambiguous set of specifications, which is properly co-ordinated with drawings and bills of quantities (if used), will certainly help in reducing enquiries and possible re-work. The cycle time for construction work will thereby be shortened and productivity will be improved. When materials are clearly specified in terms of the required properties, Just-in-time delivery can be effected to minimise wastage. The extra time spent in drafting the specifications clearly and ensuring alignment with other contract documents would be worthwhile since it is much easier to prevent or correct an error during the design stage than in the construction stage.

SIMPLIFYING COMMUNICATION

The style of writing lengthy and wordy specification clauses should be changed. A simple form of specification should be developed to cater for each specific project type, rather than adopting General Specifications that attempt to cover most situations. In this connection, the National Building Specification (NBS) in the UK has created a new trend by producing standard specifications using a "specification notes" format[7]. Project-specific details are inserted into standard clauses on a project by project basis. Alternative clauses are provided for a choice to be made on specifying by performance, proprietary products or generic properties. Performance specifications should be used only when it is essential or when detailed assessment criteria can be established.

As a means of communication, specifications should be written with the readers in mind. As pointed out by Pietroforte (1997), the more codified is the information transmitted, the smaller is the population competent to understand or interpret its meaning. Specifications containing mostly technical terminology restrict the readership to supervisors and above. This entails a process of abstracting the necessary details and translating into terminology familiar to the operatives. Mis-communication and/or inadvertent omission of essential information may occur, resulting in re-work at the contractor's cost. To mitigate against this problem, a concise checklist should accompany each section of the specifications. The supervisors can use this checklist to ensure that nothing important is being missed out.

INCREASING OUTPUT FLEXIBILITY

Specifications can be put to multiple uses if there is flexibility in the format of the document. Modern IT has made this possible. Different grouping arrangements can be effected by computer at the hit of a button instead of the traditional cut-and-shuffle. Instead of the voluminous hardcopy, specifications are now made into CD-ROMs or electronic memory cards, which are portable and can be viewed at ease (by loading into hand-held computers).

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[7] The NBS, which was launched since 1973, proclaims that it has become the de facto industry standard for specification systems in the UK with more than 4,000 office subscribers. *(http://www.nbsservices.co.uk)*

Searching for information is also handy by using search engine facilities built into the software.

INCREASING DESIGN PROCESS TRANSPARENCY

Impossib ility claims on specifications can be reduced and constructability can be improved if design consultants consult contractors during their document drafting stage. This entails a shift in the procurement approach from the traditional mode to the management-led mode whereby the contractors can participate earlier in the design process. Even if the traditional mode of appointing contractors is to be maintained, a two-stage tendering approach would help to invite potentially successful tenderers to give advice on constructability before the design is finalised.

FOCUSING CONTROL ON THE COMPLETE PROCESS

The current lack of co-ordination between various design documents (mainly drawings and specifications) occurs due to the independent preparation of these documents. If there is a concurrent production of these design documents by the same designers, there is less likelihood of co-ordination problems. There should also be independent design control, which keeps the drawings and specifications continuously under review by an overseeing panel. With the use of IT, specifications can be integrated as part of the drawings (for example, by clicking on the annotations, the screen on the computer will bring the user to the relevant specification section, which describes the materials and workmanship, or performance criteria, depending on the preferred mode of specifying).

BRINGING CONTINUOUS IMPROVEMENTS INTO THE PROCESS (i.e., "KAIZEN")

Seymour, et al (1997) criticized the current sporadic remedial actions taken to correct mistakes. They advocated long-standing efforts to address chronic problems, with attention directed towards preventing defects, rather than detecting defects and rectifying them.

Nothing can be perfect at the outset. By collecting feedback from the users of specifications, the writers can bring about improvements to the documents on a continuous basis. Research is particularly important in the area of specification writing, since developments in material production and construction processes are progressing rapidly. Keeping specifications up-to-date is a must. Strong data base support is also essential for the storage and retrieval of performance data, codes and standards.

CONCLUSION

The foregoing discussion has portrayed the problem areas of specifications under a framework of five issue groupings, namely Communication Issues, Formatting Issues, Technical Issues, Legal Issues and People Management Issues. The problems reflect the multiple roles of specifications in the construction process and highlight many of the "fat"

areas inherent in current practice. To make it lean and effective, attention should be focused on the essential roles of specifications. Being a communication tool, specifications can take many different forms to suit the particular circumstances of the project. Performance-based specifications should only be used when there are proven methods of verifying compliance. The language needs to be concise and straightforward. Being a contractual tool, the specifications should set out the obligations of the Contractor without uncertainty. As such, the specified end-results and tolerances need to be practicable and unambiguous. Being a control tool, the specifications need to be user-friendly, with the specified attributes readily verifiable, preferably on site. The requirements for approval and inspection should be streamlined to simplify the flow process. This paper has proposed some strategies for improvement based on Lean Production principles and the authors hope to stimulate further discussion to make specifications a more useful vehicle for facilitating the construction conversion process with smoother flows, higher added value, less waste and increased productivity.

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