Lean construction applied to a BIM process: how to control point attribution in MEAT tender process

Giuseppe M. Di Giuda, Valentina Villa*, Paolo E. Giana, Lavinia Chiara Tagliabue, Angelo Luigi Camillo Ciribini

Highlights

In AEC sector Lean Construction embodies the true optimization, which could be realized only in a BIM environment.

Abstract

Lean Construction (LC) and Building Information Modelling are the two methodologies linked by the same objectives. The former is an industrial optimization, which want to achieve the aim of performance increasing with the application to the AEC industry. These two concepts leaded Melzo school tender process writing. There are huge differences from a traditional process approach compared with BIM one, which leads project to a coherence high level. A deep LC principles understanding entail a distribution of the point to the different categories. The importance of LC criteria, in terms of points, imposes to the companies a change in the mind-set, from a lowest bid approach to a performance one. The study is based on the analysis of the responses to the case study procurement. Different competitors answer differently in function of Lean principles weight and their knowledge. The change in the state of mind leads the companies to offers value. In some cases, even if, many points were not able to change their behaviour. The behaviour modification will be a difficult transformation for the AEC sector.

Keywords

Lean Construction, BIM, Most Economically Advantageous Tender, Public Procurement

1. INTRODUCTION

Lean Construction (LC) methodology has the aim to reduce waste of resources and it is able to joint all the effort in obtaining an optimized result. LC is one of the major development in management and on the other side, Building Information Modelling is the main revolution in AEC field. These two subject are strictly connected, in particular, European directive 23, 24 and 25/2014 were inspired by LC methodology. They have the aim to increase freedom in the choice of the authorities (i.e. MEAT) [1], but in the meanwhile asking more skills empowering them. The European directive 24/2014 has the scope to (i) procedural simplification, (ii) reducing fragmentation of the contracting authority and (iii) estimation of the ratio of qualitative to price. A few into all these future measures will concern Building Information Modeling (BIM),
which was introduced in art. 23 c. 13 of D.Lgs. 50/2016 [1]. It was translated by the Italian legislator with the expression «methods and electronic instrument, through open format, not proprietary» this use is so close to the original one, Dir. 2014/24/UE [2], art 22 c.4, which expressed as «…specific electronic tools, such as of building information electronic modelling tools», Building Information Modelling is not just a software but, in reality, it is a process of thinking. This process is characterized by a strong partnership between the employer, on one hand, and all the suppliers and bidders (i.e. suppliers, designers, constructors, facility manager and everyone who is involved in the process), on the other. Through these methodologies, we could achieve an analytical and objective observation of the project.

2. STATE OF THE ART

Lauri Koskela defined [3] LC as a way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value. This principle acted as a new methodology for construction; in particular, it was continually developed by the International Group for Lean Construction. This methodology is based on the Theory of Production (TP) [4] optimization, which is an economic process of converting inputs into outputs [5], it is divided in three possible action (i) design, (ii) control and (iii) improvement. All the actions have to let the firm to achieve the production of the goods, minimize cost of production - but always guarantee quality - and allow correct realization of the product. The application of the theory to any kind of industry will lead to the performances improvement. Lean Construction is based on increasing building value, optimizing workflow and improving the whole instead of the parts. The first, who truly embodied the lean process in an industry, was John Krafcik with the aim of eliminating waste from the process. The novelty of his work was not in the identification of three separate concepts of construction production, but the proposal that proper construction theory must integrate all three - Transformation-Flow-Value (TFV). This means that good theory must describe fundamental principles for designing, executing and improving construction processes for the purpose of maximizing value for customer with minimized waste.

The starting point for his theory as well as for many other concepts, such as an agile management in software engineering [6], was the Toyota Production System (TPS). However, over time academics in Lean construction have pulled in various other concepts and new methodologies and tools have been developed, including the Last Planner System (Trademark of Lean Construction Institute, US) as the most prominent one [3]. If we approach to

1. INTRODUZIONE

La metodologia Lean Construction (LC) ha lo scopo di ridurre lo spreco di risorse ed è in grado di contigui tutti gli sforzi per l’ottenimento di un risultato congiunto ed ottimizzato. Si può affermare che la LC sia uno dei maggiori sviluppi nella gestione, mentre la modellazione informativa (BIM) sia la principale rivoluzione nel comparto delle costruzioni (AEC). Questi due temi sono strettamente interconnessi, in particolare le Direttive Europee 23, 24 e 25/2014 sono state ispirate dalla metodologia LC. Hanno lo scopo di aumentare la libertà nella scelta delle autorità (ad esempio OEPV) [1], ma nel frattempo hanno anche maggiori competenze alle amministrazioni che le autorizzano. La direttiva europea 24/2014 ha lo scopo di: (i) semplificazione procedurale, (ii) riduzione della frammentazione dell’amministrazione e (iii) considerazione del rapporto qualità/prezzo dell’opera. Alcune tra queste misure concernono il Building Information Modeling (BIM), che è stato introdotto nell’art. 23 c. 13 del D.Lgs. 50/2016 [1]. Tale concetto è stato tradotto dal legislatore italiano con l’espressione «metodi e strumenti elettronici, attraverso un formato aperto, non proprietario», l’espressione utilizzata è abbastanza vicina a quella del legislatore, Dir. 2014/24/UE [2], art. 22 c.4, il quale si esprime come “…strumenti elettronici specifici come la Modellazione Informativa elettronica”, tuttavia va sottolineato che Building Information Modeling non è solamente un software ma, in realtà una metodologia, un processo di pensiero caratterizzato da una profonda collaborazione tra il datore di lavoro, da un lato, e tutti i fornitori e offorrenti dall’altro (ad esempio: fornitori, progettisti, costruttori, gestori dell’impianto e tutti coloro che sono coinvolti nel processo). Attraverso queste metodologie potremmo ottenere un’osservazione analitica, coerente ed obiettiva del progetto.

2. STATO DELL’ARTE

Lauri Koskela [3] ha definito la LC come una metodologia per la progettazione di sistemi di produzione per ridurre al minimo gli sprechi di materiali, di tempi e sforzi per generare la massima quantità possibile di valore. Questo principio ha agito come una nuova metodologia per la costruzione, in particolare è stato continuamente sviluppato dall’International Group for Lean Construction. Questa metodologia si basa sull’ottimizzazione delle Teoria della Produzione (TP) [4], la quale teorizza un processo economico di trasformazione degli input in output [5], attraverso tre passaggi successivi (i) progettazione, (ii) controllo e (iii) miglioramento. Tutte le azioni devono consentire all’impresa di realizzare la produzione del componente, di ridurre al minimo i costi di produzione - ma sempre garantendo qualità - e consentire una corretta installazione del prodotto stesso. L’applicazione di questa teoria a qualsiasi tipo di industria porterà al miglioramento delle prestazioni. La Lean Construction si basa sull’almento della crescita del
construction from a point of view of an economist, we could see it as a just another kind of production. In this way, AEC could benefit from LC principles, in fact, it is an optimization of the entire workflow and choices. This idea leads him saving on different aspects and in the last period, this process, which is being expound upon and examined in depth, is closely related to BIM.

3. METHODOLOGY

According to Koskela [3] have shown that some LC principles can be applied to AEC industry. According to Sacks [7], main Lean Principles categories are (i) flow process, (ii) value generation process (iii) problem solving and (iv) developing partners, later on, Sacchi [8] continued his work and he individuated and divided the main principles of Toyota Production System (TPS).

Lean Construction impose a defined choices based on the optimization [9] of a starting point. The researchers used the project, which was the base in the bid, as a starting point, from which constructor could introduce improvement focusing their attention on different aspects. One of the main mind-change, that the new Italian tender law [1] introduced, is the ration of quality to price [10], this concept evaluates a project not on his own quality, but relates it to its price. Research team drew inspiration for the preparation of criteria used for the MEAT (Most Economically Advantageous Tender) [11] contractor’s selection in construction contract of a new primary school for about 500 students in the town of Melzo, Milan (Italy), which works amount is about 5 M€ [12] [13] [14]. A year later the tender process, ANAC (Autorità Nazionale Anticorruzione) produced a guideline [15], which describes how to deal with MEAT processes according to the same European directive on which we based the tender

One of the most important change hosted during the tender phase was the introduction of Building Information Modelling [16]. This methodology allowed us to export all the tender documents. The use of parameters in project objects let us to understand the impact of a choice on the project. In particular in the early stages, before tender, design optioeneering methods allowed us to determine where put the stress with MEAT scores[17], in this way the project was developed also according to ITACA guideline [18].

The procurement process is based (see Table 1) on (i) quantitative criteria (ii) qualitative criteria ascribable to qualitative classes (iii) qualitative subjective criteria and (iv) additional qualifications [5]. Such requests are intended to help in achieving an added value for the various stakeholders whether the owner, the Public Administration or other parties involved, increasing performance
and reducing risk, without - however - to request a surplus commitments and loans compared the real work needs.

4. CASE STUDY

The case study applied LC principles before explained to tender process to evaluate the constructor. The BIM process constituted a solid base on which the team made further development. During the tender process, a BIM model was not mandatory, but the project team decided to continue using this methodology. In particular, people and goods movements’ reduction is one of the LC methodology cardinal points – in terms of optimization of the workflow - and it has greatly influenced the Melzo primary school call for bids. The philosophy consequences can be pinpointed in many instances, such as the A.2.1 criterion. It requires an evaluation of the distance between the individual articles manufacture location and their site placement.

Four classes were chosen based on the source of the construction products; the score is inversely proportional to the distance from the construction site place. According to LC philosophy, we identified the environmental requirements and asked for the certification, both for the company and for the products (A.3 criterion) and this in accordance with the UNI EN ISO 14001. The certification claim has the strengthening purpose of the stakeholders’ confidence in the company’s environmental management system ensuring a limited impact on pollution, legal requirements fulfilment and a continued commitment to improve environmental performance.

A further judgment’s criterion content in the LC is constituted by the maintenance centre proximity for the plant component (B.2). This choice also implies a management costs reduction, thus a considerable saving in terms of both costs and intervention time, allowing a greater satisfaction of the needs and expectations of the end user. In the same way, the intelligent use of goods (B.4), both in term of energy and water consuming and health and safety of the firms (C.1) were used as parameters for the contractor evaluation. The former impacts on the energy needs of the complex and the latter on health and workers’ protection through specific procedures at working place. Also different type’s procedures of waste management (C.2.3) were evaluated: (i) the waste has been divided into four categories, reusable, recycled and disposed, which is divided into dangerous and not. This set of criteria was used to prepare the BIM model and it is subsequently exported under technical offer, through evaluation grids, for the determination of scores attributed to each participant in the tender for the contract award. The method provided, called “aggregativo compensativo” in Italian law, has

Anticorruzione) ha prodotto una linea

guida [15] la quale descrive come trattare le gare ad OEPV basandosi

sulla medesima Direttiva Europea su
cui abbiamo basato l’offerta.

Uno dei cambiamenti più importanti

introdotti nella fase dell’appalto

è stata l’introduzione del Building

Information Modeling [16]. Questa

metodologia ci ha consentito di

esporre tutti i documenti di pre-
gara. L’utilizzo di parametri negli

oggetti del progetto ci consente di

prendere l’impatto di una scelta

sullo stesso. In particolare nelle fasi

iniziali, prima dell’offerta, i metodi di

Design Optioneering, hanno permesso

tutela dell’importanza del

punteggio inserito nell’OEPV [17],
in questo modo il progetto è stato sviluppato, anche secondo la linea

guida ITACA [18].

Il processo di appalto è basato

su obbligatori, ma il team di progetto ha
deciso di continuare a utilizzare questa

metodologia. La riduzione dei flussi è

uno dei punti cardine della LC ed ha

fortemente influenzato il bando della

scuola primaria di Melzo per l’aspetto

concernente gli spostamenti di persone e beni. I riflessi di tale filosofia

si possono individuare in particolare

nella identificazione del criterio A.2.1,

nel quale viene valutata la distanza tra

la località di produzione dei singoli

manufatti e il sito di collocamento

in opera dei medesimi. Rispetto a

questo argomento sono state scelte

quattro classi che attribuiscono, in

funzione della provenienza del

manufatto, un punteggio inversamente

proporzionale alla distanza del luogo di collocazione. Secondo la
del sistema di gestione ambientale
dell’impresa garantendo un limitato
impatto in materia di inquinamento,
un soddisfazione dei requisiti
legali e un continuo impegno nel
migliorare le performance ambientali.
Un ulteriore criterio di giudizio
(B.2) contenuto nella LC è costituito
dalla vicinanza o meno di un centro
di manutenzione per la componente


di manutenzione per la componente
allowed a selection discriminating factor in disfavour of the companies which have considered minor improvements or different selection of materials based on the Lean criteria.

According to some studies made [19] BIM models are of great in helping and making more transparent the procurement management, especially with the increasing of their complexity. In this sense, Brynjolfsson and Hitt [9] state that the implementation of these processes requires changes both technological and in the procedures, which will produce economic returns in the short to medium term. These concepts, reaffirmed by Lindblada [20] emphasize that both methodological changes and management ones will have reflection both on procurement management and, also, on their criteria. The project, about the Melzo public building construction, as mentioned, was made with BIM methodology, in other words using an integrated design and conceptual methodology. The model included, therefore, all the graphics and non-graphical. It was possible to extract all the project outputs – such as building plans, sections, documents like quantity take-off or also performance specifications - as well as the offer sheets directly from the BIM model.

Because the project is a school, so a public space, the aim was the building performance improving to make it more efficient, it has been paid particular attention to the envelope performance, on MEP and HVCA, on hygiene and resources management during the building use phase. Further aspects, on which we focused on, were the materials maintainability and the technological solutions offered, as well as scheduled architectural and MEP systems maintenance.

These targets, identified at the tender process beginning and their proximity to the LC have imposed a criteria division as shown in Table 1. These principles may be divided into five categories: (a) the overall system optimization through the common targets’ identification, (b) the continuous improvement to reach the implementation of the final quality, (c) the creation of workflows for the systematic elimination of waste, (d) the fulfilment of customer requirements and (e) the quality increasing of the final good. In the model, each sub-criterion was described in a comprehensive and timely manner, the rules for granting the scores have been indicated, the formulas and the award criteria explained.

The purpose of this choice stems from the principles of transparency, non-discrimination and equal treatment. The scores attributed to the individual parties are such as not to affect the reliance object. The offers by companies must not lead to additional costs for the contracting authority, but must offer improvements from a management point of view, quality and reliability of the contracting authority.
5. RESULT ANALYSIS

The tender was attended by ten teams; one of them has not delivered a complete documentation to prove the requirements owned, did not pass the first selection stage. Just nine offers were analysed. A first consideration, that could be obtained, is the number of participant, which attended the bid; their number is extremely under the average point - which normally is around 23 participants -. It meant that a lot of participants were not able to fulfil most of the requirement or they do not have the ability to compete without using the discount as the only leverage. The result of the bid was a limited discount, about 5% instead of an average between 35 and 40% [13], so constructor nonché la loro vicinanza alla LC, hanno imposto una suddivisione dei criteri come indicato nella tabella 1. Tali principi possono essere suddivisi in cinque macro categorie: a) l’ottimizzazione complessiva del sistema attraverso l’identificazione di target comuni, (b) miglioramento continuo per il raggiungimento della qualità finale, (c) la creazione di flussi di lavoro per la sistematica eliminazione degli sprechi di tempi e costi, (d) il soddisfacimento dei requisiti della committenza ed (e) la qualità del bene finale. Nel modello, ciascun sotto-criterio è stato descritto in modo completo e dettagliato, sono state indicate le regole per l’attribuzione dei punteggi e spiegate le formule dei criteri di aggiudicazione. Lo scopo di questa scelta deriva dai principi della trasparenza, della non discriminazione e della parità di trattamento. I punteggi attribuiti alle singole
had a deep range to propose improvement. As previously described and point out in the graph 1, lean construction impacts on the companies’ offers. In particular, scores are related to each company that has achieved, connected to the above-mentioned Lean criteria, with the total scores achievable.

From data collected, it can be noted how all companies have shown interest to the Lean topics and, in particular, they had obtained, at least, 50% of the total scores (43pt in the lean topic, compared to the total 100pt), especially, one of them (6th company), has resulted awarded the contract, it has achieved almost 90% of the total score. By detailing the criteria, should be made a first comparison about the interest and efforts that, each parameter, has raised in the companies during the competition both in general terms, regardless the weight of each point (graph 2a), and considering total scores (graph 2b). The graph 2 reports the analyse relating to the first four position (5th, 6th, 8th and 9th).

Analysing the Graph 2a, we can notice how firms answered very affirmatively to the environmental requests (A.3) and about Health and Safety of the workers (C.1). These criteria request merely documentary presentation of certifications required by the client. Other ones, such as the use of resources (B.4), have found great matching between commitment and responses from construction companies; the demands on materials (A.2), which have a significant weight
in terms of points assigned (10pt), reveals a significant difference between use of resources by competitors and importance of the criterion. Similarly, even for the system components (B.2) and the aspect related to renewable energy (B.3) only two of the four companies analysed have fully responded to the requests. Obviously, the scores attributed to those criteria do not have prompted the participating companies to explore the issues. Regarding the management of the site (C.2), it can be seen against a higher score to the policy, all four companies analysed in the chart have developed very detailed proposals that led to the award of higher scores.

Graph 2. Comparison between main constructor’s firms on Lena parameters.
6. CONCLUSIONS

Lean Construction and Building Information Modelling are two methodologies linked by the same objective: reduce interferences and optimize processes, hence, the focused use of the weight allocated to a criterion (point) allow the Public Administration to reach through a MEAT [21] [22] process its tailored objective.

As shown in the previous graphs the construction companies responses were very different due to different approaches; from data, the high reaching companies emerges a change of mental paradigm - in fact in this tender each requirement has its own well defined weight – others answered as a traditional tender trying to propose a huge discount. Even with the introduction of new methodologies, AEC sector has his own old and deeply-rooted bent. This fact imposes company to have a behaviour strictly linked to a MEAT process instead of investing in the value and the research. This last fault is firmly linked to the history of tender, which chases and promotes the lowest possible price instead of MEAT process, this fact is related to a short-term vision instead of a long-term analysis, promoted by EU directive.

Throughout this new approach the Construction Industry is treated as equals as the Manufacturing Industry, changing, not only work flows but also the concept of the product quality. In this way, the introduction of some instruments, such as, the BIM, introduce many advantages, for example the decrease of design variances, reduction of fragmented linear processes, simulations of the all construction process and the visualization of the project. The weight and the scores imposed to criteria, related to the case study described in this paper, had moved contractors to deeply analyse some project aspects in order to improve the final quality of the building. The main waste created during the design and construction phase stem from improper methods of producing, managing and communicating information through all the project life. For this reason, the workflow brings greater awareness of the project’s final goal.

6. REFERENCES


portato gli appaltatori ad analizzare profondamente alcuni aspetti del progetto al fine di migliorare la qualità finale dell’edificio. I principali sprechi creati durante la fase di progetto e costruzione derivano da metodi impropri di produzione, gestione e comunicazione di informazioni attraverso l’intera vita del progetto. Per questo motivo, il flusso di lavoro porta una maggior consapevolezza dello scopo finale del progetto.