TOOLS FOR DESIGN MANAGEMENT IN BUILDING PROJECTS

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ABSTRACT

Lean Construction philosophy is increasingly being used by construction companies to improve their production; however, in this industry, such applications are most frequently in the construction phase that in the design phase.

The purpose of this paper is to propose the necessary and customised tools for applying Lean concepts to the building project design management.

As a guide, this paper uses the steps recommended in the Project Definition and Lean Design phases, based on the Lean Project Delivery System ™. It adapts each module application and selects some tools regarded as the most appropriated.

These tools have been gradually implemented in the authors' office – same that design and execute building projects - with encouraging results. Application of such simple tools has helped us to eliminate wastes and prevent redesign.

Good design management improves building project productivity and quality in other phases of the project; thus it benefits design and construction companies, as well as consumers who purchase these products. However, we consider that one of the biggest challenges is to align designers with these principles and commit these professionals to apply them.

KEY WORDS

Design management, lean project delivery system, project definition, lean design

INTRODUCTION

The Lean philosophy is being promoted and applied more often to construction projects; although, at least in our country, it is more widely applied to the construction phase than to the design phase.

The 1/10/100 rule proposed by Crosby (1979) is completely applicable to construction projects. A change or improvement in the Project Definition phase can have an impact as 1; however, in the Design phase this impact may be extended up to 10, in the Construction phase up to 100, and even in the Usage phase, it may reach 1,000 (Tilley 2005).

The current paper presents some tools for developing the Project Definition and Lean Design phases proposed by the Lean Project Delivery System. Such tools are

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presented with the aim of improving design efficiency of building projects regarding cost, quality and time.

PROJECT DEFINITION

The Project Definition phase consists of three modules with the following objectives: to determine Needs and Values, to translate them into Design Criteria, and turn them into Design Concepts (Ballard 2000).

Ballard and Zabelle (2000) rename the first module of Needs and Values and call it "Purposes". Later, Ballard (2006 and 2008) renames the second module of Design Criteria and calls it “Constraints”, keeping the name of the third module as Design Concepts.

Before discussing these three modules, it is important to clarify some aspects concerning the stakeholders and the design team.

THE STAKEHOLDERS

A building project is conceived from a group of needs, which initially may seem contrasting, but after some time of analysis and adjustments, these must complement each other in a balanced way, generating benefits for all the involved parties.

The stakeholders are defined “as being those who can influence the activities and final results of the project, whose lives or environment are positively or negatively affected by the project, and who can receive direct and indirect benefit from it.” (Takim, 2009).

Among these stakeholders, there are owners, promoters or developers, for instance, who make possible the performance and financing of the project. On the other hand, there are final users who are the reason for the project and who are going to enjoy the product, directly (families in case of housing projects) or indirectly (owners in case of resale or renting).

Governmental or private entities are also considered as stakeholders. They pronounce rules and regulations; and regulate licenses and authorizations. Finally, the design team, headed by the Project Manager, who is in charge of satisfying the needs and values, respecting the constraints and delivering a design that minimises losses for owners, promoters or developers; and generates value for the customer.

THE DESIGN TEAM

The Design team is composed of designers, main suppliers, and the project manager. This multidisciplinary team is responsible for the development of the project and the capture of needs and values of the main acting parties, as well as their materialization into constraints which together with the regulating requirements and site conditions, will serve as basis to propose design concepts.

Selection of the Design Team

The selection of the Design Team is generally performed by the project manager, the project owner and the architect, who is generally the first member of the team and is also the project manager especially in small projects.

Besides the professional fee rates demanded by every designer, it is much more important to select the design team considering some qualitative criteria to which we could apply a multi-criteria evaluation (Orihuela and Ulloa 2009).

Table 1 shows a matrix for selection of the design team taking in consideration qualitative criteria.

Table 1: Matrix for selection of the Design Team

Speciality	Names	Proffesional Fee Rate	QUALITATIVE CRITERIA WEIGHTING (1 to 5)						Total score	Selection
			Knowledge	Experience	Availability	Image	Flexibility	Delivery time		
			4	5	3	1	2	5		
			Performance							
Structural Engineering	Jhon Stevens	$ 1.6	2	2	3	1	3	4	54	
	Paul Solano	$ 1.6	5	4	2	3	2	3	68	✓
	Kenji Tanaka	$ 1.4	3	2	1	4	2	2	43	

Communication of the Design Team

In the design team, there are professionals from different fields; the relationship is less hierarchical and more horizontal. The team has mainly intracluster interaction (Hamzeh et al. 2009). In most cases, professionals do not work for the same company. Each professional works in his own office, managing his own schedule. They have sporadic meetings because of the project. Therefore, we could say that a design team is much more complex than a production team.

All this involves greater communication to minimise negative interactions, Bølviken (2010) proposes a tool called Dialogue Matrix; however, this is applicable when the group members of the design team, work together in the same place.

Table 2 shows a On Line Logbook Design, which allows for registration and concentration of all communications among the design team members; each team member has got the authority to communicate with everyone, to address to another team member, to attach any other file, or to ask for a requirement or consultation, in which case there is a check box waiting for an answer.

Table 2: On Line Logbook Design

Viewing Items: 1 to 4 (25 total)

Item	From	To	Date	Subject	Description	File	RFI
4	Arch. Ramirez	Eng. Lazo	04/04/2010	Arquitectural Project	I´m attaching the architectural project. Please, verify the section beams.		☐
3	Arch. Salas	Eng. Gomez	15/02/2010	Stairs redesign	I´m attaching a new stair design. The structural group has to present a redesing		☑
2	Eng. Gomez	All	25/01/2010	Meeting with the architectural group	There was a meeting to define the type of brick walls and slab. I´m attaching a document with the definitions		
1	Arch. Ramirez	All	12/01/2010	Meeting with the owner	There was a meeting with the owner to define the type of finishes		

The Three Modules of Project Definition

The analysis of purposes (needs and values), both of owners and final users are very important for a good project definition (Figure 1).

Waste of time is frequent because the needs and values or other constraints are not clear enough, are not available, or are wrongly assumed. One unmet demand for the owner, one solution that does not meet the user; one unknown rule or regulations; or any unconsidered site condition, will not make viable the proposed design, resulting in a major re-design.

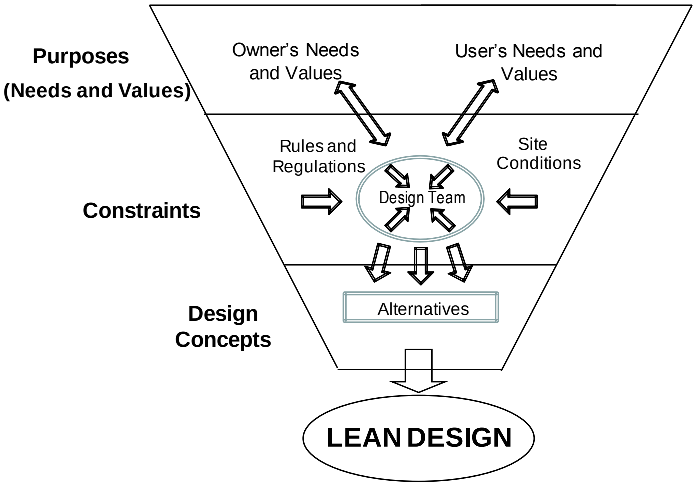

Figure 1: Modules in the Project Definition Phase (Own Source)

PURPOSES

The purposes of a project are to satisfy the needs and values of its main acting parties, who are the Owners of the projects and the Users of the product. These needs and values are not usually clear and explicit. According to Ballard (2008), clients often start by dictating means rather than revealing purpose, and rarely reveal what they are able and willing to spend to get the means for realizing their purposes.

Owners' Needs and Values

Owners, promoters or developers, who can be natural individuals, private companies or banking entities, called *"Developer"* (Ballard 2008), have got financial profitability purposes, which implies knowing maximum and minimum funds that they intend to invest, and the minimum acceptable income on their capital. The way to make their demands tangible is using the Target Cost.

This need of profitability can be measured with indicators, such as the project's Internal Rate of Return (IRR), which will have to be higher than the Minimum Attractive Rate of Return (MARR); and we can also use the Net Present Value (NPV), or the Profit Margins.

Besides the profit, owners can have other needs and desires; for example, their image inside the sector, their positioning in the market, their social responsibility, their reputation, etc. In many cases they can even be willing to sacrifice some profitability in order to comply with some of these purposes.

Table 3 presents a matrix that helps to clarify and formalise the needs and values of the project owner.

Table 3: Owners' Needs and Values

	NEED	INDICATOR	METRIC	WEIGHTING
OWNER	Profiability	Fund amount	US $ 2´000,000	5
		Term invesments	18 mounth	
		Minimun Rate of Return	24%	
		Minimun utility	15000000%	
		Risk level	Tolerable	
		Minimun margin	15%	
	Image	Positioning	N	3
		Social Responsability	Y	
		Reputation	Y	

Users' Needs and Values

To translate the users' needs and values, it is important to know the nature of their purchasing motivations in depth. For instance, a middle class user's need to purchase a house might not necessarily be shelter or comfort. His main need might be acquiring higher social status.

As in the case of owners, table 4 proposes a matrix based on multi-criteria analysis (Roche and Vejo, 2005) used to identify and weight the user's needs and values.

Table 4: Users' Needs and Values

	NEED	INDICATOR	METRIC	WEIGHTING
FINAL USER (Home buyer)	Price	Purchase amount	US $ 90,000	4
		Financing	40-60%	
	Confort	Zone	Quiet	5
		View	Outward	
		Lighting	Good	
		Ventilation	Good	
		Acustic insolation	Mediun	
		Finish bathrooms/ kitchens	Mediun	
		Area	65 a 80 m2	
		N° bedrooms	3	
	Aesthetics	Exterior aesthetics	Brick exterior	3
		Interior aesthetics	Plaster/wallpaper	
		Finish bathrooms/ kitchens	Standard	
	Security	Structural design	Verifiable	4
		Materials	Guarantee marks	
		Construction process	Quality controls	
	Warranty	Support	All the time	3
		After-sale service	Quickly	

This information will be complemented with post occupation evaluations performed in previous projects.

CONSTRAINTS

Rules and Regulations

Designs must adjust to a series of Laws, rules, and regulations, which are administered and controlled by state or private entities, and may change according to the context, the time, and the geographical location of the project. To have them as a restriction, the design team must have them available and know them in depth.

In our country, the rules and regulations change frequently, and each local government sets its own decisions, modifying them at any time.

A good practice is to have an update list with all the legal provisions and regulations of each government entity, classifying them in active and revoked. This simple option eliminates waste of time, which many times is caused by the gathering of information from different design team members; and other times, rework caused by the use of regulations that have been changed. Having this list online, available for the entire design team, we can eliminate many of these wastes.

Site Conditions

Designs must also adjust to the conditions of the place where the project will be located; for example, the urban profile, the acoustics, the field topography, the removal of immovable elements (trees, posts, drain boxes), real property lines, feasibility of public services, information about neighbors, characteristics of foundation soils, among others.

A simple tool is to have a standard check list to ensure that all this information has been taken on the site, and then make sure that has been made available to the entire design team. This simple practice will help us to eliminate rework caused by lack of this information.

DESIGN CONCEPTS

A Lean Design, in addition to complying with the restrictions, requires the choice of the best alternative. This will be the design concept that best aligned with the needs and values of Project Owners and Users of the product.

Table 5 presents a tool made up of a matrix to evaluate the degree of alignment of the purposes that each Design Concept achieves.

Table 5: Matrix of Alignment of Purposes

PURPOSE ALIGNMENT MATRIX

	NEED	VALUE WEIGHTING	PERFORMANCE OF DESIGN CONCEPTS (1 to 5)		
			Alternative 1	Alternative 2	Alternative N
OWNER	Profiability	5	2	5	3
	Image	3	5	3	4
	DEGREE OF ALIGNMENT		**25**	**34**	**27**
USERS	Price	4	5	2	3
	Confort	5	5	2	4
	Aesthetics	3	4	5	3
	Security	4	5	5	5
	Warranty	3	4	4	4
	DEGREE OF ALIGNMENT		**89**	**65**	**73**

LEAN DESIGN

The Lean Design phase begins once Project Definition has aligned purposes, constraints and design concepts. It ends when product and process design have been produced and themselves brought into alignment with the Project Definition elements. (Ballard and Zabelle 2000).

PRODUCT AND PROCESS DESIGN

Even though these two concepts have already been incipiently considered in the design concepts generation, it is during the Lean Design phase when they reach their highest level of importance.

Knowledge of procedures that will imply the construction of a building design is of great importance in this phase, this concept is called "constructability". Therefore, the whole design team should know their tasks, be aware of their responsibilities, and be in constant communication to avoid isolated advancements that could give rise to negative interactions, and, therefore, a waste of time, cost, and quality.

STRUCTURING DESIGN TASKS

In the authors' experience, in the design phase, the necessary tasks and resources to implement them are not well defined and the necessary time is not easily to estimate. Therefore, programming and control processes are usually very informal or simply not implemented. In order to structure work in the design phase, we have identified the different tasks that should be carried out during the Project Definition and the Lean Design phases, and we have elaborated some flow diagrams that signal the task sequence for the whole design team (Figure 2).

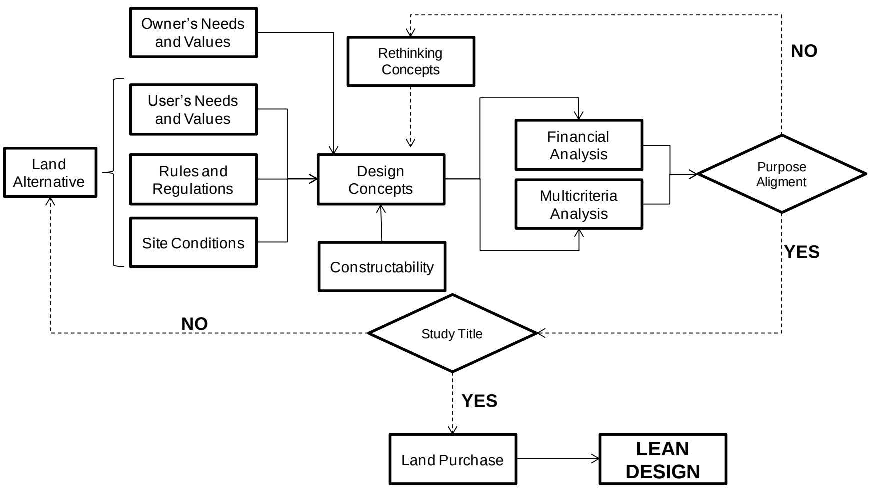

Figure 2: Structuring Design Tasks

In addition, we have found convenient to classify these design tasks in three types, using the theory of TFV (Transformation, Flow and Value) proposed by Koskela (2000):

- Internal Operational Tasks: These are in charge of the design team and their resources and times can easily be estimated. For example, data collection regarding Site Conditions. These tasks can be regarded as flow activities.

- Internal Creative Tasks: Tasks that are the design team's responsibility, but whose times are more difficult to estimate due to their own creative nature. For example, the Design Concepts generation. These tasks can be regarded as value-generating activities.

- External Tasks: Tasks which are not part of the design team's responsibilities and whose times are variable since they are made by external individuals or entities. For example, approval of the structures project by the municipal entity. These tasks can be regarded as transformation activities.

Such classification will help us to make a better estimation of time and more effective and fair control and follow up. It will also reduce conflicts that may arise due to lack of precision to meet deadlines, both within the design team cluster and between the design team and the owners.

MATRIX OF RESPONSIBILITIES

Once the design tasks and their sequences are identified, it is convenient to formalise the assignment of responsibilities for each member of the design team; a visually friendly way to do this is through a Matrix of Responsibilities. For this purpose we recommend the model proposed by Tzortzopoulos and Formoso (1999), where the design tasks are visualised on the left and the other members of the design team are shown at the top, making the assignment clear and concise. In this way, all tasks are someone's responsibility (Table 6).

Table 6: Matrix of Responsibilities (adapted from Tzortzopoulos and Formoso 1999)

Design Task	Type of Task	Design Team								
		Project Manager	Owner	Local goverment	Architec	Surveyor	Structural enginee	Electrical engineer	Supplier of elevato	Sanitary engineer
Feseability of electric power	EX							R		
Checking of the boundaries	INO					E				
Design of pre project	INC				E					
Pre project approbal by owner	INO	C	R							
Pre project approbal by municipality	EX			E						
Selecting the type of elevators	INO	C	C		R				C	
Sizing of cistern	INO				C					E
Type of pumping	INO	C								R
Type of roof slab	INO	C					R			

EX = External Tasks
INO = Internal Operational Tasks
INC = Internal Creative Tasks

R = Reponsible
E = Ejecuting
C = Co-operating

EARLY IDENTIFICATION OF MATERIALS AND COMPONENTS

Even though many of the materials and components used to build the project are frequently defined only in the construction phase, its early selection will avoid losses and re-processes. For example, architectural plans can consider a certain thickness of brick walls that have got no relation with the thickness of the unit masonry that will actually be used in the building work. Therefore, architectural dimensions and details of the confined columns will later have to be adjusted. Similarly, because of this indefiniteness, the structural design will probably consider the most critical situation, in other words, the heavier unit masonry.

The same occurs with the incorporation of some construction components. For example, due to the lack of precision about the type of lightweight slab to be used, the structural design will probably assume the calculus with beams poured on site, and if we are going to use precast beams, these slabs will have to be re-calculated which, as its name suggests, is a double work.

Checklists with the different alternatives of those materials and components that will be necessary define before start the design, help to make the best choices and prevent future redesigns.

In order to choose the best alternative, a multi-criterion evaluation could also be used (Orihuela and Ulloa, 2009.)

CONCLUSIONS

This paper provides some customised tools to manage building project design and develop each one of the modules of the Project Definition and Lean Design phases, based on the Lean Project Delivery System.

The paper proposes simple tools to improve the selection of members of the design team and the communication among them. It introduces matrices to identify and assess the needs and values of project owners and product users, and proposes a way to choose the best design concept that aligns with their primary purposes.

It recommends the use of a checklist to obtain field data, thus preventing redesign. It also recommends the use of array of responsibilities and the use of a flow chart in order to formalise the tasks and to engage the design team.

With the aim to differentiate responsibilities and improve time estimation, a design task classification is also proposed: creative internal task, operational internal task and external task.

Finally, the use of a checklist is recommended to facilitate the choice of materials and building components, which must be defined before beginning the design, thus preventing future redesigns.

BIBLIOGRAPHY

Ballard, G. (2000). “Lean Project Delivery System”. White Paper # 8, Lean Construction Institute, September 23, 2000, 7 pp. (avaliable in “Readings” www.leanconstruction.org).

Ballard, G and Zabelle, T. (2000). “Project Definition”. White Paper # 9, Lean Construction Institute, Octuber 20, 2000, 10 pp. (avaliable in “Readings” www.leanconstruction.org).

Ballard, G and Zabelle, T. (2000). “Lean Design: Process, Tools and Techniques”. White Paper # 10, Lean Construction Institute, Octuber 20, 2000, 15 pp. (avaliable in “Readings” www.leanconstruction.org)

Ballard, G. (2006). “Rethinking Project Definition in Terms of Target Costing”. *Proceedings of the 14 th Annual Conference of the International Group for Lean Construction*, IGLC 14, 25 -27 July, Santiago, Chile, pp. 77- 89.

Ballard, G. (2008). “The Lean Project Delivery System: An Update”. *Lean Construction Journal*, pp. 1-19.

Bølviken, T., Gullbrekken, B. y Nyseth, K. (2010). “Collaborative Design Management”. *Proceedings of the 18 th Annual Conference of the International Group for Lean Construction*, IGLC 18, 14 -16 July, Haifa, Israel, pp. 103- 112.

Crosby, P.B. (1979),Quality is Free: The Art of Making Quality Certain, New American Library, New York,352 pp.

Koskela, L. (2000). “An Exploration towards a Production Theory and its Application to Construction”. PhD Dissertation, VTT Building Technology, Espoo, Finland. 296 pp., VTT Publications: 408, ISBN 951-38-5565-1; 951-38-5566-X. (available at http://www.leanconstruction.org)

Orihuela, P. and Ulloa, K. (2009). “Metodología para Promover la Ingeniería Basada en Múltiples Alternativas”. *Proceedings of the 3rd Latin-American Conference on Construction Management and Economics*, ELAGEC 3, 9-11 September, Bogotá, Colombia, pp. 295-307. (avaliable at http://elagec3.uniandes.edu.co/memorias_elagec_III.pdf)

Roche H. and Vejo, C. (2005). “Análisis Multicriterio en la Toma de Decisiones” (available at http://www.ccee.edu.uy/ensenian/catmetad/material/MdA-Scoring-AHP.pdf)

Takim, R. (2009). “The Management of Stakeholders’ Needs and Expectations in the Development of Construction Project in Malaysia”. Modern Applied Science Jounral, Vol. 3 Nº 5, May Issue, pp. 167-175.(available at http://www.ccsenet.org/journal/index.php/mas)

Tilley, P. (2005). “Lean Design Management – A New Paradigm for Managing the Design and Documentation Process to Improve Quality?”. *Proceedings of the 13 th Annual Conference of the Internation Group for Lean Construction*, IGLC 13, 18-20 July, Sydney, Australia, pp. 283-295.

Tzortzopoulos, P. and Formoso, C. (1999). “Consideration on Application of Lean Construction Principles to Design Management”. *Proceedings of the 7th Annual Conference of the Internation Group of Lean Construction*, IGLC 7, 26-28 July, Berkley, California, USA, pp. 335-344.