

# **DESIGNING FOR LEAN CONSTRUCTION**

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## **ABSTRACT**

This paper proposes an initial draft of guidelines to fit design methods based on lean construction principles. It results into innovative design procedures that can illustrate the application of “lean thinking design” for production efficiency improvement in building construction companies.

The main concepts related to lean construction are discussed under design and production points of view as well as the optimal managerial relations among building design procedures and production activities. An experience of using innovative design methods is described as a practical reference.

The proposed design methodology results in changes to the traditional design team arrangement and also to the design development and co-ordination. The difficulties for the implementation of the proposal in building construction companies are briefly examined.

## **KEY WORDS**

Lean construction, building design, building construction.

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## **INTRODUCTION**

In Brazil, concerning the design management procedures, construction companies are nowadays trying to implement a new model of design development that allows an easier introduction of better technological efficiency. The design concept for these companies has already changed.

Because of the increasing complexity of building design, several construction companies, at São Paulo building construction market, have been looking for a better coordination among the several parts that compose the building design (e.g., architecture, structure, building services, production detailing, etc). The current approach of design also includes the need of a closer relationship between design and construction. This should be created through the introduction of the production process design, which can lead to the implementation of lean production principles in building construction, and intends to solve the potential constructability problems before the beginning of the construction activities on the site.

Nowadays, the challenge of design management is the integration of the various design specialties and the associated reestablishment of their duties and responsibilities. The question to be discussed, thus, is how to use lean production philosophy to promote the necessary changes in the design process.

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

- increase the efficiency of value adding activities, associated to the improvement of production technology and production skills;
- reduce the share of non value adding activities, leading to simplification, reduction of variability and increasing flexibility;
- ensure product specifications, thus improving customer value;
- and improve in a comprehensive and integrated way, balancing actions oriented to implement lean production principles in design, control and production systems.

In the sequence, this paper intends to take a look over the application of these principles to the building design methodology.

## **LEAN THINKING DESIGN**

Corbett et al. (1993) take into account that the most essential guidance to provide the success of the any product design development is the simultaneous elaboration of its production process design. This requires a multifunctional team working together since the very beginning of the design process, contrasting to the traditional design way, which is based in a serial development of design, submitted to an analysis sequence through different professionals.

Sonnenwald (1996), helping to the efficiency improvement of industrial production by serial processes, comment that many companies adopted concurrent engineering principles, thus emphasizing the knowledge integration into the comprehensive production process, breaking old barriers between “design” and “production”. The

information technology resources has been responsible for a significant aid in this field, since it allows the intensive data sharing among all the design professionals involved.

According to Corbett et al. (1993), in the past, product designs reached their end before its production process solution had been considered. For this reason, cost savings were more difficult to be obtained, since design review became more complex, expensive and its rejection, increased. One of the most important goals of concurrent engineering is prevent the occurrence of these problems, through the integration of activities and decisions, improving comprehensively the efficiency of the process.

The reduction of uncertainty and of time to the completion, using essentially a team approach, tool integration and partnering, that is the power of the simultaneity in design.

By concurrent engineering principles, customer requirements are met through the study of the best possible alternatives of solution, as a well-oriented composition of different and distinct points of view.

### **EXPERIENCE OF USING INNOVATIVE DESIGN METHODS**

This case study refers to a work involving a Brazilian private building company, which is carrying out during a 12-month cooperative research program among University of São Paulo and this company. The conclusions described here are a partial result of this program.

It is a company that executes externally contracted building works or its own projects. As it expresses an expectation on a well oriented income growth, specially based on the second mentioned group of projects, the company carried out an extensive reorganization program. The main objective related to design co-ordination subject was to develop a methodology in order to establish an integrated performing of design and production processes.

The first activity of the research program consisted of a diagnosis focusing the company internal relations and the performance of its main departments, concerning their influence over design management. It was essential to provide basic comprehension about: ordinary procedures; responsibilities division; non-satisfied expectations; and other related features.

The diagnosis permitted the identification of several factors that were affecting design characteristics and aimed at the proposal of methodological changes in the usual procedures. These factors are listed and explained below:

1. As different performing areas, real estate developing and building were separated but undefined and incoherent activities, without a common acting philosophy; this separation among fundamental activities did not aim to implement essential procedure changes;
2. Reflecting the management deficiency problem, there were non-specified subjects in the designers contracts; they were only informally oriented by very busy co-ordinators;
3. The real estate developer "culture" included low-expensive design; associated to this minimum expense, there was a practice of minimizing the design solutions detailing, reducing its accuracy and utility, specially in terms of buildability;
4. The emphasis on the product itself, like an exclusively marketing problem, was very predominant during the first stage of the project; as a result, almost all

technological questions were not discussed, so they could not influence the designed characteristics;

5. The design co-ordination process was too informal that it generated a non-documented and poor integration of design parts; as a result, design documents were full of wrong or missing information and they had a poor reputation among site personnel;
6. There were no systematic criteria for decision making to orient design work, concerning buildability needs; during the design detailing stage, site operations efficiency was not properly considered;
7. The analysis of design as information to the production process was not possible, since detailed information was available only at the end of design process;
8. The practice of maintaining some finishing material specifications undefined, until someone asks for them, was a significant barrier; this situation remained until suppliers or site personnel needed the specification to buy the materials or contract the services.

Most of the constructive details were not useful, since they were presented to describe only the product final appearance or specific characteristics, but the details did not show how the product had to be built; and, furthermore, presented incoherent dimensional data and missing information.

During this research program about design management problems in that private building company, involving the production of buildings, it was possible to develop a group of guidelines to a new design methodology, considering the special needs of this kind of design. These guidelines are briefly explained in the next section.

## **DESIGN TEAM ARRANGEMENT, DESIGN DEVELOPMENT, AND DESIGN CO-ORDINATION**

Building design can be defined as “an activity or service that is an integral part of the building construction process, dealing with development, organization, documentation and transmission of information on the specified physical and technological characteristics that must be considered in the construction phase of a particular project” (Melhado 1994).

Under this view, to transmit information on the characteristics of the building, design must be considered as much more than drawing and description. Design “must be interpreted not only as an architectural and engineering problem, since it is a multifunctional work that involves from marketing and costs analysis to technological choices and production process specifications” (Melhado 1995).

Searching for a new methodology that would consider the difficulties above mentioned and would include the necessary changes to achieve efficiency improvement objectives, some guidelines were proposed to design co-ordination process. Those methodological guidelines, that will involve either internal or external relationship, since both of them influence design management, are the following:

- Product and production process must be equally considered, since the very early beginning of design process -- it means a significant value-adding improvement;

- The post-occupancy systematic evaluation must be implemented as a part of a feedback information system that aims at designers and prevent some possible repetition of technological specification and detailing errors;
- Building design, as a multidisciplinary activity, needs a multidisciplinary team of several specialized designers and consultants working together since the very early stage of design process;
- Design co-ordination needs pre-established parameters and criteria in order to orient, analyze and criticize design solutions properly;
- Design management involves not only design review procedures, which are related to the real estate developing and the construction companies, but also a well supervised quality control procedure inside the contracted design firm;
- Supply, work training, technological development, design and production processes must be oriented by the same statements of an organizational program that a company is implementing.

The proposals of a multifunctional teamwork and the new building design methodology are illustrated in figures 1 and 2.

Multifunctional work requests a great co-ordination effort to assure that all design professionals are informed of any change along the design process to be successful. If there is a really fast exchange of information, it is possible to avoid the occurrence of mistakes, incoherent specification and incompatibilities that can demand future revisions in the design developed, increasing the time until design completion.

The role of design co-ordination should be simply playing forward to the project goal. This can be translated as a matter of assuring that each design team member will perform his maximum potential of data integration and knowledge exchange, producing a design solution without deficiencies of compatibility and coherence, then adding value to other design parts and to the project as a whole.

As a result, building companies and design offices would be engaged in a qualitative revision of their relations and procedures all over the activities involved in the design elaboration, to produce a new approach of building design. The new approach will certainly promote the creation of a wide professional field to design team managers that may be performing one of the most strategic functions in construction projects.

## **CONCURRENT ENGINEERING AND CONCEPT OF DESIGN FOR PRODUCTION**

Concurrent engineering approach in the serial industry is typically defined as “the integration of both the product and the manufacturing design processes”, adding that “the goal of this integration is to reduce both product development time and cost, and to provide a product that better meets the customer’s expectations” (Noble 1993).

In the traditional building construction, the approach of the architectural design, as well the design methods used by the structural and building services engineering, develop mainly the “product” design. The inclusion of parameters linked to the production design is a very important statement to a methodological review of the building design process.

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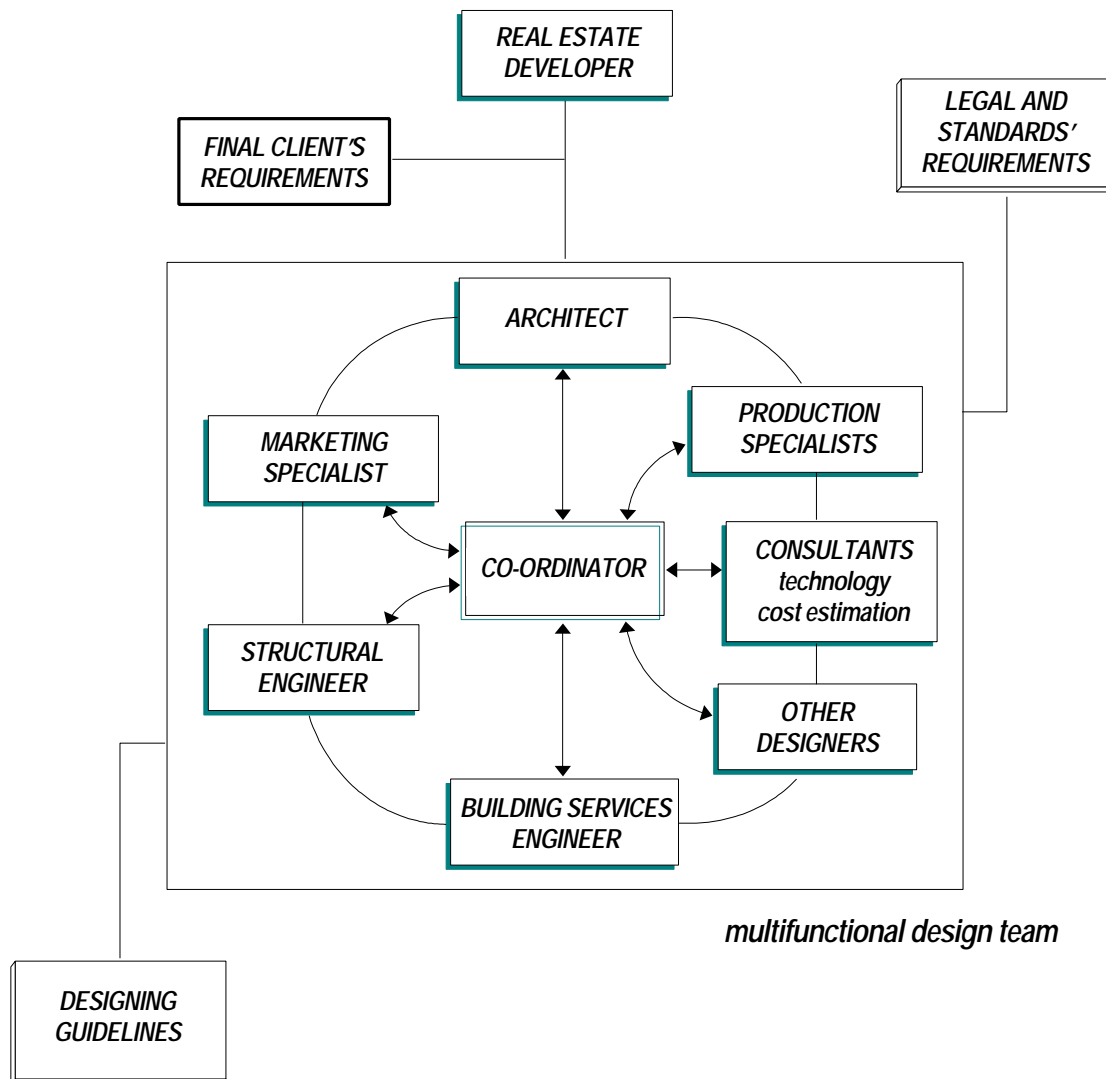


Figure 1: Proposal of multifunctional team to the building design elaboration (Melhado 1994)

The implementation of the concept of design for production can be obtained through the inclusion of a new type of design consultant, who deals with the development and detailing under the design for production point-of-view. Design for production generates the production process design, which is defined in the field of building construction as: ‘a group of design elements concurrently elaborated with definite product design, defining the arrangement and sequence of production activities, equipment utilization, building site planning and evolution, and other information linked to the resources and characteristics of a construction company’ (Melhado 1994).

*Design for production* focuses the ‘concurrent design’ of the building parts that are considered critical for quality achievement, e.g., formwork, partition walls, floor detailing, external rendering, waterproofing, and so on. Step by step, design for production becomes increasingly common in building construction, using information

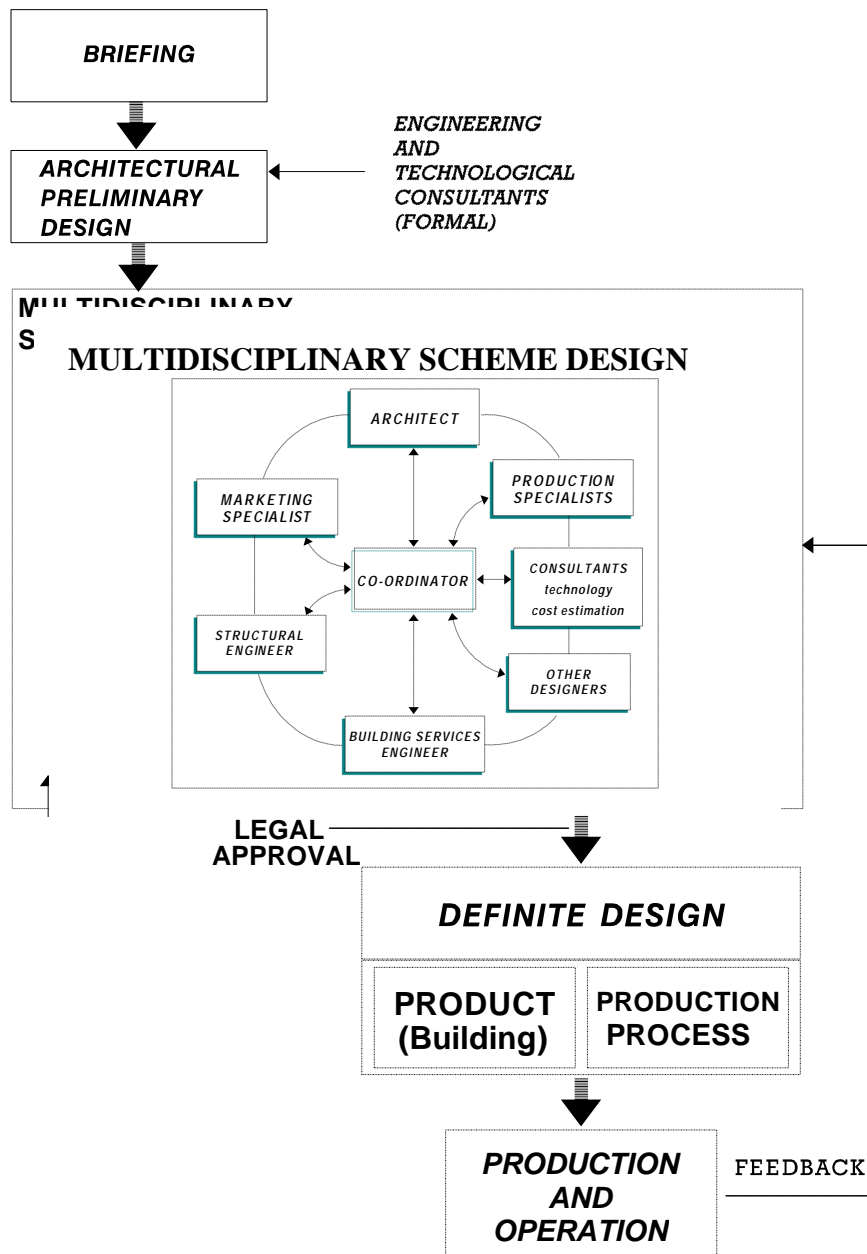


Figure 2: Proposed design procedure considering the guidelines for quality improvement (adapted from Melhado and Agopyan 1996)

data provided by several design professionals and aiming to cross information and to promote a more integrated design.

In the same direction, construction companies can adopt a *database on construction technology*, as proposed by Melhado (1994), that allows the creation of a constructive memory that can give feedback to future projects of the same company. Design professionals, through an “on line” accessing of this database, shall minimize the

compatibility problems that happened in past projects, using the information registered in the construction technology database of the building company.

It would be even possible to reprocess the data used in the building design for cost estimation, supplying and contracting, production detailing, etc.

## **DIFFICULTIES FOR IMPLEMENTATION OF THIS PROPOSAL**

With the current competitiveness, full of new requirements from clients, design teams are gradually including a growing number of consultants that need to develop and integrate their specialties with the purpose of proposing better and better solutions that can demonstrate a differential both in terms of product requirements and in terms of information for production.

A representative example of this trend is the inclusion of specific information for production in the product detailing, ie, for production designing. Design phase, thus, is beginning to incorporate construction knowledge.

Making a parallel, it is possible to observe that the communication process in the serial production industry, involving the integration among several specialized fields and the integration of design decisions, inside a concurrent engineering environment, is nowadays emerging as an essential part of design methodology, at the same time that information technology and its computational applications are recognized as important tools.

The construction industry, as any other production sector, is already presenting the same kind of tendency, but in a less arranged configuration.

In the case study, as many problems were spotted when analyzing the above-mentioned company, we proposed the described guidelines in order to feel how they would work. The implementation of the new design methodology had been conducted through an experimental way, adopting a project to a preliminary introduction of the new procedure. Although people involved were convinced that the adoption of this proposed methodology would enable the company to get best quality results, some difficulties remained.

One of the most critical factors for successful design co-ordination is the level of efficiency in the team internal communication, that has implications for the duration of the project development stages and the quality of the design solution, as a whole.

The first difficulty of a series can appear in the early beginning, when it was necessary to create the multidisciplinary team and choose its co-ordinator. The discussion about rights and responsibilities division, as a whole, tends to become non-consensual. The real estate developing company wants to get all things under control till the legal presentation has been done. On the other hand, the construction company does not agree with it, since on that way it is not possible the use of lean construction principles, influencing conceptual design solutions.

In the case study, at the end, the directors of the holding company, which comprises the building and the real estate developing companies, forced all the executives to a compulsory change of their positions and the design team had to be co-ordinated by the real estate develop company or the construction company leaders, depending on the specificity of each subject, what were previously defined.

Another difficulty that created a significant barrier involved the designers' contracts, which were postponed until the limit, trying to save some money in the first stage of this project. The new methodology anticipates the usual payments to designers and creates



also new ones, what seems to the real estate developer a not so useful thing, considering just only his own objectives; to improve design quality, design stages have to incorporate all specialists sooner.

When the design process started, some designers reacted friendly to those new demands, while others did not understand the asking of different information and presentation of it to their design parts. It was demonstrated, again, how people motivation and belief is an essential part of any reorganization program.

## FINAL REMARKS

The implementation of construction and control procedures into building construction has disclosed the weakness of the traditional design process in considering strict specification and definition of the construction activity. A conceptual design full of details is not the answer to the production requirements and now it must have a very straight relation to the procedures that several designers had never been taught to consider in their jobs.

The results of the design procedure conceptual changes are undoubtedly significant to improve production efficiency, in terms of buildability and production costs control, which are essentially concerned about the essential principles of *lean construction*.

Design can be more than several paper sheets containing definite drawings and specifications, turning to a flexible and complete data source and making the recycling of design solutions possible, even during the construction phase of building projects.

The work-in-simultaneity of different teams involved in the same project, which requires an efficient co-ordination, is replacing the old model that makes independent parts into mistaken project subdivision. As design work becomes multifunctional, it becomes more substantial, too. This new design process eliminates not only waste, but also the non-adding value tasks.

However, the strategy of real estate development often leads to a wrong use of this design potential and concentrates the focus only in the product. The production process is not analyzed properly until the completion of the product conception, postponing the analysis of the constructive attributes of the design solution, as well as its cost estimation.

To answer both expectations, about the improvement of effectiveness concerning the constructive process, and the other one, which deals with functional requirements of the product, there is a strong necessity for a new and powerful methodology. For this purpose, it must be used a more “industrial” approach and an integrated design elaboration is one of the most critical factors of the expected efficiency improvement in the building production practices.

## REFERENCES

- Barclay, B. and Carter, D. (1992). *Concurrent Engineering: the product development environment for the 1990s*. Addison-Wesley, Massachusetts.
- Corbett et al. (1993). *Design for manufacture: strategies, principles and techniques*. Massachusetts, Addison-Wesley.
- Koskela, L. (1998). “Lean construction.” In: *Encontro Nacional de Tecnologia do Ambiente Construído*, 7th. Qualidade no Processo Construtivo: proceedings. Florianópolis, April, NPC/ECV/CTC/UFSC. pp. 3-10.
- Melhado, S.B. and Agopyan, V. (1996). “Design quality concept to improve building quality.” *Proc. CIB W 65 Intl. Symp.*, The Organisation and Management of Construction—Shaping Theory and Practice. Glasgow, Sept., Vol. 2, pp. 502-508.

- Melhado, S.B. (1994). *Qualidade do projeto na construção de edifícios: aplicação ao caso das empresas de incorporação e construção*. Doctorate Thesis, Escola Politécnica, Universidade de São Paulo.
- Melhado, S.B. (1995). “O que é qualidade de projeto?: uma discussão acerca das mudanças conceituais necessárias para a melhoria da qualidade na construção de edificações.” In: *Proc. Workshop Qualidade de Projeto/RS*, Porto Alegre. Porto Alegre, Departamento de Engenharia Civil/Escola Politécnica/PUC-RS.
- Noble, J.S. (1993). *Economic design in concurrent engineering. Concurrent engineering: contemporary issues and modern design tools*. Chapman & Hall, Cambridge. pp. 352-371.
- Sonnenwald, D.H. (1996). “Communication roles that support collaboration during the design process.” *Design Studies*, 17 (3) June.