

E CONCURRENT ENGINEERING IN CONSTRUCTION: STUDIES OF BRIEF-DESIGN INTEGRATION

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ABSTRACT

The design process is influenced by the estate developers and programmers of the construction projects, which are co-responsible for the briefing and for designers selection. The design, in turn, has the mission of transforming the brief into design specifications and defining products (buildings) and its production process.

Often, both of these moments of a new project involve interactions between developers and designers, with consequent redefinition into the brief and the design. So, the proposed quality and design development depends on the interface between brief developing and product detailing, as well as cooperation and communication among involved players.

This paper, through bibliographical and local studies characterizes the interface between briefing and design; analyses the main deficiencies and show solutions for optimise relationship between players and the management of the design process.

KEYWORDS

Lean construction, Project planning, Design Management, Concurrent Design.

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INTRODUCTION

The Lean Construction philosophy focuses on the necessity to consider the productive processes, according to the point of view of the conversion (efficiency in the transformation activities), of the flow (global efficiency and efficiency in organizing process) and according to the point of view of clients value aggregation.

Traditionally, a conversion perspective is guided by a strong fragmentation and hierarchization of the design in disciplines and independent players guides the buildings project process. As consequence, it is observed that several designers, consultants and project players are mobilized to contribute along this design process taking part with their respective interests and knowledge in developing formulations of independent parts and decisions about the design. These decisions are conditioned by chronograms, legislations, economic and financial availabilities, technological and constructive possibilities, etc.

As a result of this fragmentation, it is verified *different interfaces among main involved players* that imply in the need of *different suitableness* and reworks in designs to assure coherence among relative decisions so as to the project as to designs' development.

Concurrent Engineering approach emphasizes exactly the design flows and the role of the design in adding value to the clients. The more classic definition to Concurrent Engineering (CE) is "...a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developer, from the outset, to consider all elements of the product lifecycle from concept through disposal, including quality control, cost, scheduling and user requirements." (Institute for Defense Analyses – IDA, 1988) apud (SPCD 2002). And, the fundamentals of CE, according to several authors, as Hartley (1992), Love; Gunasekaran (1997), among others, are:

- Multidisciplinary team participants interaction incentive, emphasizing designs coordinator role;
- Concurrent product development process stages execution. Specially, product and production designs integrated development;
- Design integration of production process different player's approaches. This is expected to occur by multidisciplinary team implementation that considers, while elaborating the design, the product life cycle;
- Strong client and user satisfaction orientation (transformation of clients desires into design specification), eliminating activities that don't add value to the product.

At this work, the design process is taken by a wide perspective that represents a reliable tool for profiting Lean Construction goals: *better meeting client needs while using less of everything* (Howell 1999). Thus, the design process considers all the decisions and ideas that aim to subsidize the mounting, creation and the production of an project, from the mounting of the immovable operation, passing through the briefing formulation until the development of production design, of 'as built' design and of the evaluation users satisfaction with the product.

Tending to analyze the administration of design process faced the practices of real estate and building segment projects, the current article identifies five main design interfaces along the project (see next item). And, the focus of investigation is the **ii** (as shown below) interface between the mounting of business program and the building design and to complement the theoretical analyzes about the importance and form of the

organization this interface, were accomplished two studies of cases in construction companies and Brazilian incorporations.

INTERFACES OF THE DESIGN PROCESS

The 5 interfaces identified can be divided into two blocks: **(i1), (i2) and (i3)**, interfaces of **the developing product that are potentially concurrent**; and **(i4) and (i5)**, that can be considered interfaces of **design performance feedback** in execution and use.

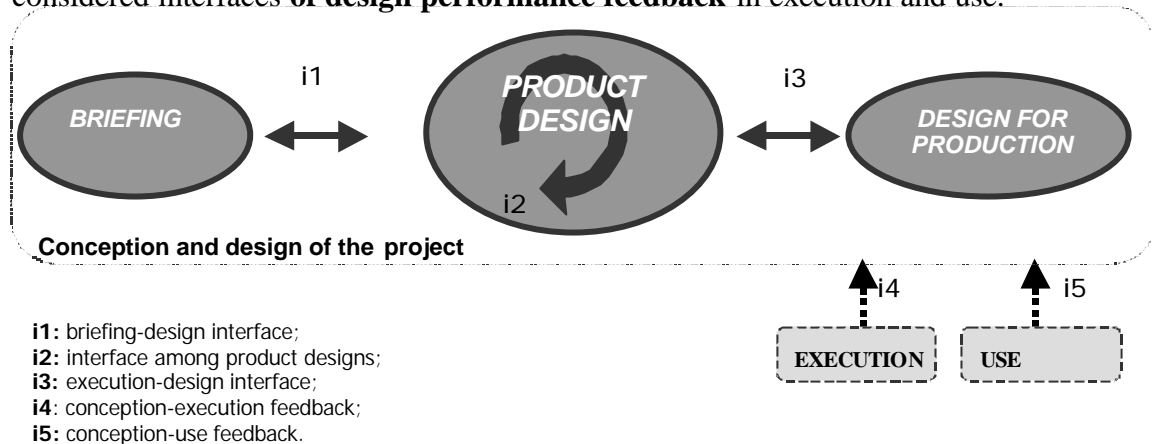


Figure 1: Main interfaces of the conception design and design of the immovable projects.

The first interface **(i1)**, briefing-design, is focused on collaboration between business conception and clients needs specification with creation and product development. Therefore, it corresponds to concatenation of briefing conception efforts and product design conception including the programmer and designers, mainly architects.

Interface among the specialties designers **(i2)** is related with the coordination in the designers' performance and in the parallel development of different design disciplines.

The interface **(i3)** is related to design buildability and to elaboration of design for production that is solved in advance and in a concomitant way with the product specifications and also the works subsystems constructive methods. Interface **(i4)** represents the need of execution accompaniment and elaboration of 'as built' drawings to assure the future designs feedback and the building maintenance.

Interface **(i5)** is related to project accompaniment during its use and maintenance phase, in order to check the reached results and the clients' satisfaction. Through performance and Post Occupation Evaluation (POE) that investigates building technical performance and user perceptions, they supply results that feed the processes of new projects development to create a dynamic learning and refinement of the projects.

BRIEFING-DESIGN INTERFACE

ESTABLISHING THE BRIEFING OF THE PROJECT

The briefing of a building construction design is defined in the Brazilian Standard NBR 13531 as the step destined to the determination of the established character demands or of performance (needs and users' expectations) to be satisfied by the construction to be conceived (ABNT 1995).

According to Kamara *et al.* (2001), the *briefing* should introduce clients and users' requirements for design, being the starting point for the development of the functional and

project constructive solutions. Motteu; Cnudde (1989), Hall; Fletcher (1989) defend a similar opinion: it is through the *briefing* that clients explain their needs, their financial possibilities and their requisitions related with the project.

However, in the real estate and building segment, the briefing is associated with the development and formulation of a business listed by project sale speed and by the profitability rates according to investors and programmers. Thus, the programmer, beginning with the identification of a potential demand of market, takes the decision of initiating the project, he mounts the business – always considering investors' availability and financial players' restrictions – and then, he initiates the *project* formulation.

In summary, project briefing should establish business goals and designs requirements in a coordinated way. In general, three kinds of requirements are discussed in the briefing:

- Business goals, referring to the market segment or target demand, funds selection, project costs, financing terms depending on the kind of project, sale speed and desired profitability, etc.;
- Functional, space and operational requirements that guide product development;
- Constructive character requirements as terms, execution quality, construction costs, etc.

These requirements are, clearly, mutually dependents and hierarchical. This way, for example, the economic viability given by the project, condition target briefing, its construction cost and product characteristics should be suitable with the market segment, destinies, project location, etc.

To answer to the formulation of these requirements, Kamara et al. (2001) suggests that the briefing development process involves two stages:

- Strategic or initial program: it develops the adorns and the key-goals, like global budget, general specifications of the project besides the funds selection;
- Briefing: it consists in a complete specification of the functional requirements, operational and constructive requirements for developing design, translating strategic program goals in requirements for the design

Akin; Flanagan (1995) apud Green; Simister (1999) still aim a third stage, previous, of investigation of clients needs and culture in order to bring up parameters that drive the program strategic definitions.

The briefing formulation program is influenced by the work of one or more architects with the programmer, but, in general, they are only mobilized to take part in the briefing development or in the formulation of the strategic program, that is represented by studies of viability and of constructive possibilities investigation in face to the legal restrictions and to ground characteristics. Besides the involvement depth, the engagement of these professionals is generally based on a 'risk contract' in which the professional's fees only will be paid when the project is launched.

As point Green; Simister (1999), the identification of the clients needs and of business opportunities through the briefing depends less on the ability to conceive design solutions and more on the capacity to understand the clients and to take strategic decisions. Thus, it is necessary to rely on architects' practical experience and programmers to develop the briefing since the academic and the sector formal formations do not privilege this kind of content.

Taken the decision of carry on one of the studies options, it passes for the briefing development. At this step, the design requirements development is variable being accomplished with larger or smaller depth and in accordance with own methodologies to each programmer. Like so, briefing definition occurs in a little systematic form and relatively independent on others phases of design process, marking the first spin-off in the process between designers and programmer's performance.

In this first design process moment, the programmer has a clear role of conception related to the choice of the ground, creation, mounting and proposal of a briefing, activity for which, in general, he relies on architect's help.

The programmer is also in charge of designers selection and engagement, which are going to develop product projects and projects for production. In fact, in Brazilian building construction the project programmer makes the selection of architecture and engineering designers, in most cases. However, this model is not rigid and neither universal. It is possible to find in Brazil some cases in which the architect or the project design coordinator are in charge of the designer's selection and the engagement.

DEVELOPING THE PRODUCT DESIGN

In Brazil, the building design teams are composed by different designers hired by the programmer to act in the development of projects, whose course determines the mobilization degree of the designers with it.

It is hired, firstly, the architect that factually conceives the product that afterwards will be complemented by specialties projects. Many times, architectural conception is finished without participation of others designers, except some consultations to structural designer that are used in design process before the others engineering specialties.

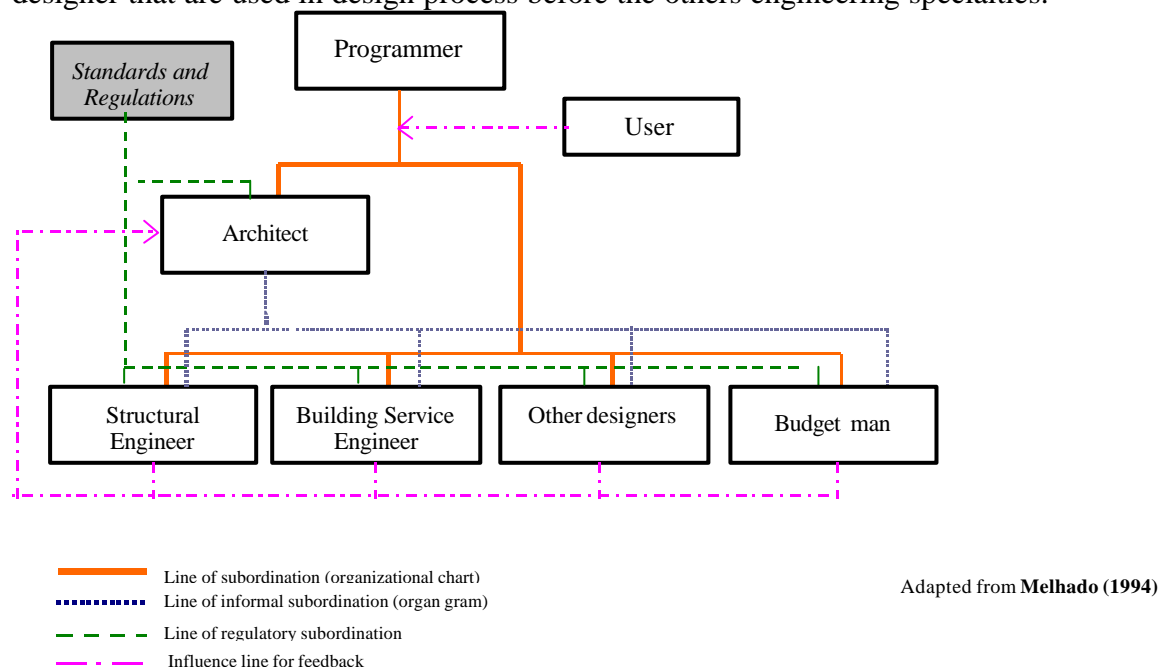


Figure 2: 'Organization Chart' of the traditional design team

Several works as Castells; Heineck's (2001), Freut; Formoso's, 1993 focus a tendency in subdivide the product design elaboration in two separated and independent steps. The first being performed by architecture offices and more focused on conception and formulation,

and the second one related to the options technological development selected, exercised by the engineering of the building company or for independent offices. Like so, for Castells; Heineck (2001), the first step is focused on qualitative elaboration and the second one is mostly focused on quantitative development.

The architect’s primacy in the design process is, according to Melhado (1994), backed also in technical rules in effect, as well as in institutional texts that care for the subject and that consider the architecture design as the responsible person for the indications to be followed by the structures and facilities designs.

This way, it is common that a design step of certain specialty depends, to be initiated, on the finish of a different specialty stage, which is deepening and maturity degree of decisions is equivalent to the step (of the other specialty) that we initiate. For example, the beginning of the structures and foundations design has as prerequisite finished (or almost) architectural design.

Thus, we realize that the architectural conception phase of building occurs in a separated form from design development, in other words, architect’s performance occurs previously and with reduced interaction with the others designers and site work engineers. In fact, in Brazilian building industry, many times, only after a new release step, the engagement of others units who are going to take part in design development is made.

Like this, the institutional arrangement and design process practices can be classified as highly hierarchical and they are developed in a sequential way, with the design team modifying itself along the design process, by the mobilization and demobilization of the different specialties.

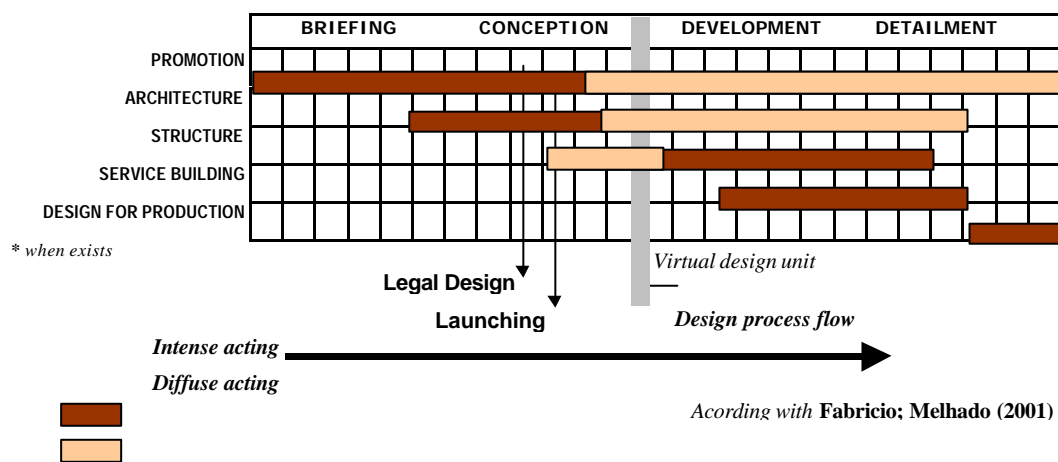


Figure 3: Generic outline of a sequential process of development of building design – participation of the players along process.

The sequential process in use makes that only the architecture designer takes direct contact with the project programming. Other designers leave from the design or previous design of architecture and of adopted solutions in this discipline to develop technical solutions that “complement” the architecture design. Like this, the briefing is shown to the engineering designers through the design drawings and solutions previously adopted in the architectural design. Although it is stronger related to the architectural design, it is possible to verify, along the whole project, a hierarchy that makes designers face the

project, take contact with its briefing through developed projected solutions and not through treaty problems.

Kamara et al. (2001) highlights that this indirect contact of many designers with the briefing backwashes in solutions that, probably, do not fully satisfy the clients needs, limiting the possibility of several designers with the original problem, once that they set out from solutions previously defined and not from a cast of necessities.

In this fragmented and sequential process, the possibility of collaboration between designers is very reduced and problematic; and the proposal of modifications by a designer of a specific specialist implies in reviewing projects already more matured, meaning enormous reworks or even the quit of whole projects. In fact, as the project is developed and detailed, the free proposal of solutions and changes decrease (Melhado, 1994) and, in a process in which designers are mobilized in sequence, the possibility of intervention of designers, in solution conception is also reduced.

In design process prevails the Cartesian vision meaning that the all is the sum of independent parts. That is predominant in the configuration of process of traditional projects in which we seek to optimize the all from the optimization, in separated, from the parts – what is not the truth in most of the cases! In fact it is understood that a systematic approach in design process could make possible a better control on their phases, with no loose in the whole domain.

According to Melhado (2001), without an intense exchange of information among the players during project development, the result is a: *badly defined, badly specified and badly resolved project* resulting in increasing costs and runtime.

INTERFACE WITH CLIENT

About the analysis of the establishment of the briefing of the project, and the development of the product design (item above) we realize that in the environment of developing the Brazilian real estate and building projects, the product design briefing and conception are known as distinct steps with own participants and characteristics.

However, the briefing represents not only the starting data for the design, but it configures in essence the client interaction with design process. In building construction, the interface between client and the project is given by briefing, which should translate client wishes and needs in attributes and specifications for the design.

“The knowledge of the users’ importance for the project result is, in the industrialized world, one of the significant verifications of these last years. In fact, traditionally, it was thought that project difficulty resided essentially in the capacity of seeking a satisfactory answer for the starting question that, it could not occasion the problem. The current empiric studies as the recent theoretical developments give emphasis, on the other side, about importance and the target definition difficulty in terms of project functional goal.” (Jouini; Midler 1996, p25-26)

One of design process main difficulties is to identify the markets and understand the clients’ demands. In other words, it is not enough to ask what the clients wish, because, many times, their answers are inconclusive, too much ambitious, conflicting and mutually incompatible. It is necessary to understand their needs and wishes and ‘negotiates’ the several demands to obtain practicable combinations and at the same time satisfactory to the clients and competitive in the market.

Lots of designers highlight frequent changes in the briefing as a barrier to the good development of the design.

According to Kamara *et al.* (2001), for a design development that satisfies the clients needs and aspiration, it is necessary the existence of a good briefing without ambiguities: “The definition of needs to which should answer the new product is not a staring data, but a construction that constitutes one of the project critical aspects and that is developed dialectically with the research of possible answers”. (Jouini; Midler 1996)

Thus, the development of briefing is really misty, being ruled by vacant requests that complicate the process management (Jiao; Tseng 1999). Then, in lots of cases clients requests are conflicting to each other, being fundamental the capacity of managing conflicts and to seek joint solutions of design and briefing that assure the best assistance to clients cravings.

The collaboration between business conception and the needs specification with the product creation and design investigation is fundamental to assure, not only the complying of requirements included in the briefing, but the optimization of the demands and clients requirements who are many times incompatible and should be consolidated in the exploration of the possible design solutions. Therefore, the collaboration should occur since programming process beginning and also should seek briefing options including production needs in order to reduce the risk of changes in the briefing and reworks in the design in latest design stages. Changes are necessary to reach such goal in culture and in project players’ organization structure.

Traditionally only the architect has direct contact with the briefing requirements mounting while other designers set out from formulations and architecture design dealings. This way, it is possible to unstuck the project requirements of the original programmatic requirements and limiting the possibility of these designers contribute in the double briefing-design optimization.

For this purpose it is necessary that this interface involves all the design specialties so that the solutions conception are integrated and guided to the requirements, without being conditioned by previous solutions of designers.

And the organizational functional-hierarchic (figure 2) predominant in the building projects is watertight according to integrated development of the interface **ii**.

In the search for organizational agility, it is necessary that the design units be mounted to privilege the interactivity and communication among players. So, it can be valid the multidisciplinary structure of design proposed by Melhado (1994), showed in Fig.4.

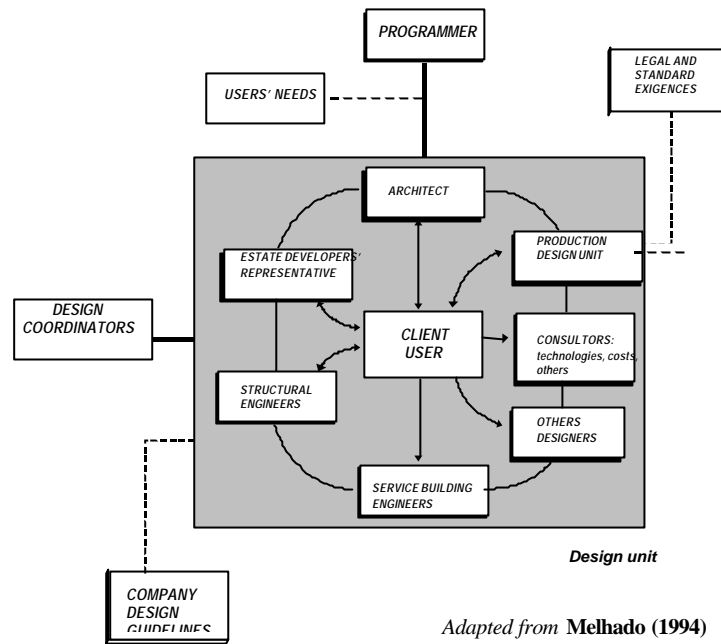


Figure 4: Design Multidisciplinary Unit.

With this organizational arrangement, the design process is guided for the clients and users satisfaction and it is subordinated to two commands according to a structure characterized as die collaborative. Mainly considering clients, once these establish, or at least they would owe, the relative requirements to the final product, flowing then, the relative decisions to process formatting (relative to players and suppliers) and product formatting (briefing definition, constructive system, budgets).

While the design coordinator is responsible for the accomplishment of the design goals (terms, budgets, etc.) and for fomenting the interaction among design unit members, the programmer is assigned of providing resources and giving support to the design process, and then, in some cases, he can be responsible for the group selection that integrates the design unit.

The design coordination should have as purpose not only turn compatible the several design specialties, but also to optimize, since the beginning of designs, the several activities and interfaces that will compose the life cycle of the product.

CASE STUDIES

Considering the interfaces of collaboration mentioned and focusing the interface **ii**, two case studies were developed in building companies and incorporation to investigate the practices and the possibilities of simultaneous integration between product briefing and design.

The **company A** is a real estate firm that builds great dwelling projects, acting in the market of middle class in several cities of Brazil but, with strong concentration in the metropolitan region of São Paulo.

The competitive strategy of this company had focused on the search of cost reduction and improvement of sales terms to make possible the direct purchase of apartments for the middle class consumers. This company mounted a project auto-financing outline in

which considerable part of the construction costs are financed by the clients through consortium and payment period lengthening.

The lengthening of construction terms influences a series of briefing and design decisions. Initially, the choice of fast constructive options does not have a great importance, once that the speed of project is not certain by the technical limits but, by the payment capacity of clients. This points to the technologies valorization that propitiates smaller costs of execution independent of the runtime required.

In this context, the adoption of industrialized constructive and precasted techniques is not stimulated in detriment to the traditional constructive processes, more adequate and flexible to the tune 'work speed \times payment speed'. Thus, the search of constructive options makes possible a slow execution of works at the same time that allows to retarding costs, meeting to the clients' desire of 'watch work walking', at the same time in which they assure cash flow in best terms of the project (Assumpção 1996).

However, the company gives special importance to clients cravings and a series of marketing actions as the consecrate divulging and marks specification for certain materials and constructive components (especially the finishing) implying in the previous definition to the conception and in a range of options for finishing specifications to be adopted in design.

In company A, the design program is derivative of a pre-established basic briefing, developed by the regional directories of product and marketing. Market experience of each company regional and qualitative researches are accomplished with the potential consumer enable the elaboration of basic briefing. With this, for each country region, where the company acts, target-briefings are developed to contemplate regional peculiarities (larger balconies in coast in general, balcony with barbecue set in Porto Alegre, shuttlecock block in the 'Triângulo Mineiro' region, etc.)

The ground choice is one of the project first conception decisions, is subordinate to the search of suitable lots to the kind of product and to the client' niche who the company wants to reach. From there onwards the briefing definitions follow the pre-established standards by the company.

Based on the descriptive definitions (basic briefings) of products that attend to the market niches selected, the company developed a series of rules and conception procedures and design that guide the project development.

The commitment of designers allows partnerships with professionals familiarized with company practices and their restrictions, recommendations and presentation rules, besides following to the criteria of suppliers' qualification and evaluation of the Quality Management System (QMS) of the company. The concern in design production is, according to company, incorporated in the definite design of product and in production rules and procedures of QMS and, in masonry specific case, in a third party design for production.

In the **company B**, the case study approaches an organization with 35 years of market and performance consolidated in the states of Minas Gerais, Distrito Federal and eight years ago in São Paulo market. The company originally was focused on the high-income residential market, following classical strategies of market, with regard to the new release of its projects, such as a research of financial viability, or the own financing of its projects. A second line market consists on flats and hotels segment. The company has a certified QMS against to ISO 9002: 1994.

In company B, the grounds selection for acquisition or swap is guided by its location and opportunity to incorporate good areas, acting in preferential districts in each city. As company works with more elevated standard segment, its projects briefing definition is accomplished in a more custom-made set than usual market practices.

For briefing definition, all the teams are mobilized: the real estate team (marketing and design analyst, financial analyst, prospector of grounds), the company technical area (superintendent, design coordinator, the ones responsible for the briefing) and the architect hired, while engineering designers are hired in a second moment.

The several product designs (architecture, structure, facilities...) are subcontracted. Company also accomplishes design for production of a series of building subsystems (e.g.: forms design, window-frame, facade coating, masonry). These projects are subcontracted and developed simultaneously with the product design, except for the formwork design that is done later. Designers' commitment allows the previous experiences, the designers' qualification and evaluation, according to company QMS and, as last criterion, the indication and market references.

From the **il** interface point of view (briefing-design), the companies set out from traditional references of market, valorizing the consolidated definitions in the practice and in the sale of previous projects and, occasionally, by the accomplishment of market qualitative researches.

In the case of company A, the briefing integration with the other conception areas is strongly guided for a target-briefing, that subsidizes the project briefing and a design development manual guiding the product design with functional and standardized constructive requirements. In company B, the briefing is made case to case, what allows an interface **il** more cooperative regarding to company "A", characterizing a situation in which the design requirements are developed by the programmer specifically to the project and, not rarely, the functional briefing remains vacant and it establishes few criteria for the design process (of the product and production).

It is interesting to report that in both cases, no POE of projects is requested by clients, but just as an evaluation done as a part of QMS routines. Although this tool doesn't configure a formal activity to be performed in **il**, it gives in fact a feedback that makes more accurate clients aims for the project (**i5**). This is a lack that was shown in "interface with client" item.

CONCLUSION

Adding value to products means a crucial skill not only in Lean Construction philosophy but also to everyone that is looking for competitiveness. Concerning building construction processes, briefing and design, understanding and developing accurate design solutions are fundamental for client. In fact, briefing and designing means two instances in the same challenge of new products conception that must be solved into a balance.

The presented case studies point to the increasing concern in terms of design management process done by building construction companies, particularly the briefing-design interface. But it also points to difficulties and low integration between these interfaces.

Concerning the CE fundamentals, the studies show some links that can be highlighted: multidisciplinary teams participants composed as early as possible, when participation and integration of designers from different disciplines is not frequent; and client

satisfaction orientation which is not yet real, although it is an objective aimed by the whole team, which tries to get it using different tools.

The analysis carried out shows that integrated and simultaneous development of briefing and design demands cultural changes, partnership between design players, and organizational changes, along with hierarchic levels and setting up design structures focused on the concurrent effort and guided by the clients perspective.

At all, the authors propose adding specific experiments to move practice forward such as a clear definition of clients' longings allied to the participation of architects and design coordinators in this process, once they have the practical experience not always considered by clients, during decision process. By reducing uncertainties, these initial stages allow most appropriate project planning, and consequently, systematic project integration.

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