

THE IMPORTANCE OF THE DESIGN FOR PRODUCTION IN THE DESIGN PROCESS MANAGEMENT IN BUILDING CONSTRUCTION

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ABSTRACT

The design model, hitherto adopted by building companies, is sequential, lacks coordination and, most of the time is disengaged from the production process. It is now undergoing reformulation because of the intense concern with quality in this sector. Building companies are beginning to admit the importance of the production chain, with design acting as an element which preempts problems on the building site. The design process management assumes large importance in lean construction: adopting constructability principles; minimizing waste and reducing time.

In this field of action, the design for production has been put to use by building companies to improve the production process, since it holds the necessary elements. Inserted in the design process, it seeks to support continuous improvement on building sites.

The present work intends to evaluate the importance of the design for production in the design process management, checking its validation while being a support element to the production. It is intended to do this via a bibliographic review and a case study of a building and incorporating company in the state of Sao Paulo. This work will put in focus the improvement of quality of the design process through the introduction of several designs for production (masonry, rendering, etc.), and the reduction of waste with design and production costs by their use.

KEYWORDS

Design process, Design for production and Constructability, Lean Construction, Building Construction.

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INTRODUCTION

Of the factors affecting the quality of the final product in civil construction, it is pointed out that little importance is given to the conception stage and the design development. Apart from the peculiarities noticed in the sector, which determine the grade of complexity of its products and make difficult the implementation of quality management systems, the traditional way of designing reveals itself as intervening in the process of constructing. The design, traditionally, is developed by several process players (architects, engineers of different specialties), without, for the most part, an efficient means of coordinating them, which warrants the success of the global undertaking as for the stated solutions concerning the aspects of the final product and its process.

For many years, the importance of the design's role in the undertaking context was not recognized because it was assumed to play a comparatively insignificant role in influencing project duration and execution costs.

However, Souza et al. (1994) point out that "it is on the project stage that the conception and the development of the product takes place, which must be based on the identification of the clients' requirements in terms of performance and cost and the conditions of exposition which the building will be submitted to. The quality of the design solution will determine the quality of the product and, consequently, will condition the final users' satisfaction".

The design solution adopted has also high impact on the work execution process, because it defines parties, constructive details and specifications that allow a larger or smaller facility of building and which affect the production costs. The quality of the project depends on the quality of the solution description, as a result of the clarity and precision of the executive project, the estimation and dimension memorials (*memoriais de cálculo e de dimensionamento*) and the technical specifications (Souza 1997).

Melhado (1998) notices: "the design elaboration stage assumes relevance while working as an essential character information's systematizer and transmitter to the efficiency of the productive activity, standing out as essential link of the production chain. The implementation of Quality Management Systems (QMS) in civil construction has made possible to the sector reorganize its production process, contributing to its continuous improvement, not only by the aspect of its presentation, but also because companies have realized that is no longer possible to stay in the same conditions of 15 years ago, when high wastes and low productivity were conceived; nowadays market is highly competitive, and only those who know how to manage their production process well will survive.

In this context, there was also a reorganization of the design stage, understanding the importance and the potential the design presents to the development of the undertaking. Melhado (2001) comments on that this contemporary view brings the design a more systemic focus, coherent to the needs showed by the consumer market, in constant evolution, decrease of cost and increase of competition.

Building companies are using the Design for Production (DP) as a new element in the design process, and its importance to the integration between the design and the execution stage has been acknowledged. There are problems concerning the systematics to its implantation, implying in deficiencies, concerning its appropriate use. However, the concepts concerning constructability and the constructive rationalization must be

presented at once during the design, and the DP acts transmitting these restrict character information to the work.

THE CONSTRUCTIVE RATIONALIZATION AND THE DESIGN PROCESS

The concept of constructive rationalization has been quite used in building construction in the latest years, by reason of the movement by the quality presented in the sector.

In search of waste reduction and the increase of productivity, rationalization has been adopted as element in the improvement of the process. This is inserted in the concept of lean production adopted by Grenn (1999), who states: “Lean production consists of a complex cocktail of ideas including continuous improvement, flattened organization structures, elimination of waste, efficient use of resources and cooperative supply chain management”.

Rosso (1980) apud Barros (1996) concepts rationalization as “a set of reformer actions that are intended to substitute the daily conventional practices and methods based on systematic reasoning, aiming to eliminate the chances in the decisions”. These statements lead to the conclusion that the substitution of conventional practices by methods based on principles of organization and predefinition of activities, rescuing back to the beginning of the production process the rationalization of an appropriate activity or process. To this same author, the building needs to be rationalized at his stage of conception, when there is possibility of reaching better results.

To Sabbatini (1989), constructive rationalization “ is a process composed of a set of all actions aiming to optimize the use of material, human, organizational, energetic, technological, temporal and financial resources in the construction in all its stages”.

Franco and Agopyan (1993) point out the importance of constructive rationalization since the first stages of the undertaking, emphasizing that the project stage is the most favorable stage to introduce most of the steps that aim rationalization. Melhado (1994) elucidates the contribution given by the design process organization, inside a program established in a company, in order to reach the aims of the technological evolution and of the constructive rationalization.

Therefore, the principles that guide the constructive rationalization are linked to the improvement of the production process, without, however, implying in a sudden rupture of this process. These actions or principles must be introduced, according to several authors, in the initial sage, that is, in the project stage. Barros (1996) points out that rationalization must be applied in an ample way in the production process, including all the undertaking stages, since its conception, passing through the execution and planning stages and getting to the building’s maintenance.

The design exercises an important role as a transmitter of these rationalization actions, and, at this moment, when solutions are being meditated, there is a better possibility of interference concerning the effective application of these actions in the site work.

Besides that, the diffusion of these actions is better assimilated when comes from the design, reaching several undertaking levels. At this aspect, the design for production has large importance as it works as a link between the project and the work, systematizing and transmitting all the information and actions meditated previously to the execution stage, allowing it to be fulfilled more efficiently.

THE PRINCIPLE OF CONSTRUCTABILITY GUIDING THE DESIGN PROCESS

The definition of constructability from the Construction Industry Research and Information Association *apud* Souza (1996) refers to the grade in which the building design helps to make easy the execution, answering all the demands about performance and quality needed to the conclusion of the building.

Griffith (1987) *apud* Melhado (1994) makes explicit some results that may come from the effective application of the concept of construct ability:

- Simplification of the design taking into account an easier execution in the building site;
- More precise and efficacious communication of the purposes included in the design;
- Execution management in a more efficacious in site work;
- Better usage of the available resources to designing and to building.

The constructability philosophy proposes that in the act of designing must be taken into account solutions that make easier the way of building, not excluding the use of innovatory solutions, but meditating on them aiming to aggregate worth to the final product, which is the building itself. In addition to, the available technologies in the market must be susceptible to their employment in the building company, always taking into account the constructive technology adopted by this organization.

The design must be meditated on taking into account the philosophy of construct ability. Sabbatini (1989) emphasizes: “To optimize the whole construction process, it is necessary to consolidate, at the design stage, the factors related to the constructive operations”.

Melhado (1994) considers that the constructability philosophy is indispensable at the design stage. According to him, it is extremely important to incorporate the production factors to the design, by way of a complete integration between design and production, making possible to this design, among other attributions, to be of use as an effective link of information and technological transmission.

The DP proposes to anticipate execution, and under this point of view, it must be composed of construct ability aspects, by way of the constructive rationalization may occur appropriately in the site work, besides contemplating the best solutions concerning the way of building up.

THE DESIGN FOR PRODUCTION (DP) IN BUILDING CONSTRUCTION

ORIGIN AND CONCEPT

Some authors have proposed important actions in the reduction of problems resulting from the design development stage, the conventional way it is treated. The qualification of designers may be quoted, being adopted some evaluation standards to the contracts, not prevailing the evaluation for the lowest price, but for the capacity and the specialty of each one, as well as the disposition to the work attendance; adoption of a design methodology that results in a propose to take decisions and resolution of problems in the interfaces; coordination of designs adopting principles of concurrent engineering;

standardization of the execution procedures by way of the consolidation of organization constructive culture be established; adoption of *designs for production*; feedback through an appropriate information system offering continuous improvement of the subsequent designs (Melhado 1998).

The design for production (DP), quoted by Melhado (1994) commonly described in other works, such as Souza et al. (1994) and Novaes (1998), as a design that integrates the design stage to the execution phase has been pointed out as a mechanism to the solution of several conception stage problems and of design development, and very recently practiced in civil construction. Serial products industry has been already using it for a long time in its processes, as a tool to reach quality excellence of its products and to improve its production process, integrating them.

According to Cambiaghi's opinion (1992), "the incorporating and building companies are searching for new technologies, new constructive systems, smaller construction costs, and all this requires that the design conception be meditated together with the constructive system, by way of the design development be economically viable". Melhado (1994) emphasizes: "the design elaboration involving the product design and the design for production may represent the way to the solution of problems concerning in the Building Construction".

The concept of DP has its origin in the serial industry essentially, being meditated on as a way of coordinating the product solutions with production process alternatives. Stool (1991) emphasizes the importance of developing products and process simultaneously, aiming to integrate and to optimize globally the product production cycles. In relation to building construction, Melhado (1994) defines design for production as "a set of design elements developed in simultaneous way to the detail of the executive design for use in the ambit of the activities of work's production, presenting the following definitions: disposition and sequence of service fronts and work's activities; arrangement and evolution of the site work; from among others items linked to own characteristics and resources of the building company.

THE DESIGN FOR PRODUCTION AS A CHANGING PLAYER IN THE DESIGN PROCESS

Melhado and Fabrício (1998) point out that the production characterization (designs for Production) along with the development of the product (Product designs) have as one of their functions allowing a better translation the product's characteristics and specifications in production procedures and sequences, minimizing the possibility of an inappropriate or incomplete execution of these specifications.

According to Zegarra et al. "the demand for DP turned to definition and detail of production of certain subsystems of the building". This fact allows to say that with the enlargement of the use of these designs, turned to the work's execution, the possibility of improving the design's conception and development and the integration between designers and constructors also increase.

It is necessary to create a link that may strait relationships between designers and constructors, by way of the design solutions be meditated on together, in a way that the don't be postponed to the work's execution stage, meditating on modifications of the previous design, wastes, incoherent solutions with the way of building up, from among others.

It is noticed that the DP may exercise a fundamental role in the decrease of costs, relative to the wastes due to the lack of production control and total domination of the constructive process, besides constituting a way to the improvement of the final product, through the anticipation of probable execution problems. It is undiscussible the importance of the design to the final quality of the undertaking, working as an instrument of viability of the whole process and presenting large capacity in the adoption of solutions that promote the continuous improvement of building's production process in civil construction. Problems occurred at this stage of the process (the design) has damaged the quality of the product (the building), which, usually are only perceived by the time of the delivery of it or at the execution stage, and the decisions are taken momentarily. The DP, whose main objective is to integrate the design to the execution, presenting appropriate solutions to improve the execution process of a specific subsystem, has been adopted by several building companies in search of the systematic reduction of these problems. From among the most used DP, stand out: masonry, ceramic tile covering, impermeability, structural masonry, and rationalized slabs.

Souza (1996) points out: "the DP's essential role is to solve questions involving the adoption of a established constructive technology, including in terms of specification alternatives and details of the product itself, along the elaboration of the product by way of inserting the construct ability and constructive rationalization conditional elements, ending with the presentation of a defined production process, allowing its control and assuring the desirable quality to the product". Besides that, DP, foreseeing the execution process, can also anticipate and prevent the occurrence of a series of pathological problems, besides reducing the construction's cost.

However, DP must not be exhaustively and exaggeratedly detailed, making complex its comprehension, but it must give necessary information to the appropriate production, and must be harmonized with the available manpower's characteristics (Souza et al. 1995).

The importance of DP introduction of the building product subsystems is recognized by technicians' as a way of making viable the production in highly competitive market context, in which it is desirable to reduce wastes and increase productivity. Besides that, the search for quality through the introduction of quality management systems in the building companies has interfered in the way of seeing the existent relations between the several agents of the building's production chain, emphasizing the design's elaboration and conception stage, in which the creation of the DP is inserted, whose use perspectives are increasing.

MAIN DIFFICULTIES IN THE DP'S IMPLANTATION

Besides the organizational questions, which affect the introduction of these DP in the building companies, inhibiting their potential, other difficulties pointed out by Souza et al. (1995) are quoted, like the lack of existence of specialized designers building companies' skepticism and impatience concerning the results, and the difficulty of integrating several designs and DP.

However, Souza (1996) points out: "despite building companies are at an incipient design development stage, viewing the product and the production, there is already for part of these companies a large consciousness concerning their importance, what lead to believe that they consider DP an instrument to lever the quality in the building's construction, proportioning a more rationalized and economic constructive process".

CASE STUDY

The studied company is a constructing and incorporating company acting in the commercial and residential market of property for 35 years in the State of Sao Paulo. In relation to residential market, the company build up from medium-high standard buildings to popular habitations.

The company is considered a medium-port company, according to the design manager. It is been certified for a year through the standard series ISO 9001 version 2000. The company has presented, until the end of the year 2001 about 18 undertakings under way and 20 buildings at the design stage. The table of employees is about 300 working in the offices, 200 at works and 800 indirect employees, that is, subcontracted employees.

THE DESIGN PROCESS IN THE COMPANY

The company's design flow is checked next:

- The design starts in the incorporation with the product's definition – briefing;
- Layout – simple plan with the division of spaces;
- Architecture, structures and installation's pre-design – designers put in motion;
- Legal design;
- Executive projects, including landscape gardening – Contracted projectors;
- Masonry, tile covering, dry wall and moulds design for production – first meeting: design parameters' checking.
- design delivery – designers and building engineers' meeting;
- Execution planning;
- Production;
- Product delivery;
- *As-built* design;
- feedback design process

According to the flow shown in the previous design, the DP is made along with the executive designs. Despite keeping a sequential structure concerning the architecture designs' fulfillment, structures and installations, there is concern by way of the designs be developed simultaneously and the solutions be meditated on globally.

After the production and executive design definition, they are delivered and a designers and engineers' meeting takes place, to check the designs. If some irregularity is verified, the engineer requests a change in the design, through a formulary (FOR 55). This formulary returns to the design management, which analyzes the requests. This posture adopted by the company reveals itself fragile once it allows to take design decisions at the stage of consolidation of solutions. The engineers should be present during the development of these designs, presenting coherent solutions to the way of building up.

Despite the DP be developed previously to the work's execution stage, the re-design is meditated on by reason of the interaction between the several subsystems, what may alter the solutions initially proposed. For example, front tile covering interaction with masonry and structure. Even existing an initial DP, by reason of the design's conditions don't be totally answered, there is a re-design, taking into account the real parameters, which avoid improvisations in the site work.

In relation to the design's coordination, the company believes that this concept, which has been introduced for few years, has contributed to the design's quality acquisition, not expecting other important actions. The design's manager makes this coordination internally. According to him, the architecture office should make this coordination, but he believes, due to his previous experiences, that architects are not prepared to assume this posture, "for they don't understand the building up activity". Usually 4 major residential undertaking coordination meetings are held along the design process, and when it is necessary, minor meetings are held with specific designers. In case of commercial undertakings, meetings are more intense, due to their complexity, and 2 meetings may be held monthly.

The company's designers develop the DP. To the design manager, these designers are more used to the company's constructive technology, and therefore they have conditions of designing easily. This decision was taken as an external consulting recommendation.

The main DP's developed are: masonry, dry wall, tile covering, moulds, granite's pagination, etc. What led the company to adopt these designs was the possibility of creating better and more uniform solutions to the execution stage, anticipation of the work, decrease of the improvisation level in the building sites, besides the increase of productivity and improvement of the final product's quality offered.

To the design manager, these DP's answer the production because they are made internally, what makes easy the identification of main problems often occurred in the works, working as entrance data to their elaboration. Another question commented by him is that DP works when the design department is concerned with following the design development, not considering that its work ends when it is delivered to the work. "If there is concerns, the DP's will be in constant development".

Besides the benefits come from the use of these DP's and from the design's coordination, the company points out some still existent difficulties in the design process that must be minimized, such as: designs keep on getting late at the work; the available design in the work usually it's not the latest version, occurring confusion most of times; impasse in relation to the design sequence; deficiencies in the compatibility; resistance for part of the engineers and employees, concerning the DP, considering it as a pile of paper in the work. Nowadays the company has been implanting a server on the Internet with passwords, allowing the several designers to check the designs of their own office, that is, allowing the design boards 'changing. In the work, the engineer can access a master list containing all the design's modifications, being possible to check its latest version. The feedback process is made through the *as-built* design.

Besides that, the company recognizes the evolution in the design process occurred in the latest years, mainly with the introduction of QMS (quality management system). It is noticed the large potential the project has over the undertaking development, being a tool to be used as a differential to the acquisition of the building's quality, therefore, it needs to suffer constant evolutions. DP has been already incorporated to the company's design process and has contributed to the best development at this stage.

CONCLUSIONS

The design process has passed through evolution along the years and has contributed effectively to the acquisition of the building's quality. The directives proposed by Melhado (1994) to the design's conception and elaboration, which by that time seemed little susceptible to building companies, today are considered as fundamental aspects, whose inclusion is checked little by little in the design process.

The advent of the Quality Management Systems' implementation introduce actions and postures, important in relation to the design, commented on by Reis (1998), but it's considered that the consciousness of the real potential presented by this stage has been the great changing impel force occurred in the existent design flows. All these efforts are fruits of years of researches and works made, concerning the design and have shown the importance the design has, while being an efficient information instrument and the importance of considering the aspects of construct ability and constructive rationalization since the first undertaking stages, to assure the success of these actions.

In this evolution context, the design for production emerges as an integration mechanism between the design and the production. This kind of design has been developed by serial industry for some time, being recently used in civil construction (CC). The necessity of introducing this design in civil construction emerges from several difficulties found in the by design for production reason of the executive design shows only the design's definitions, without, however, taking into account the way of building this product up. These difficulties were meditated on in the act of execution, through improvisations in the building sites due to the lack of a design's definition that would contemplate the execution.

Some designs for production of several subsystems are already developed, including by specialized companies. But, in the face of this changing process, there is the concern that these designs be used in an appropriate way, without losing their initial purpose, which is answering the production's requirements. There is a fear that DP becomes one more project subject and shows the same problems faced in the process so far.

Therefore, the building company must be prepared, from the undertaking management's point of view, by way of the design for production's insertion presents all the conditions of being used appropriately. It is believed that DP must be meditated on together with other design subjects, contributing to broach better solutions to the execution. There are, still, difficulties in the DP's coordination and other designers. It is believed that the relationships may become more harmonious due to the perception of the importance of the introduction of these designs in the undertaking development.

DP is a reality in the companies' design process context, and its importance is recognized as a link between the design and the execution. There is no doubt it constitutes a changing agent in this process once it was not conceived in civil construction industry so far. DP breaks the sector's inertia barricades, implying it to a new design process, in which the product cannot be meditated on dissociated from the production.

However, it is necessary the creation of a methodology to these design for production development and implantation, integrating the design and the production in an appropriate way, and the creation of mechanisms of usage and development analysis of these designs for production in the building's constructing market, understanding its main implantation difficulties.

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