

EFFECTS OF THE DEMAND OF ENVIRONMENTAL SUSTAINABILITY ON THE BUILDING DESIGN STAGE



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Summary

Civil Construction products, particularly buildings, have an impact on the environment, consuming resources and generating waste throughout their life cycle. The design stage has strong influence on the quality and performance of the products, and can thus be a strategic stage to adopt mitigating solutions for environmental impacts. There is a demand for more sustainable design solutions today, originated by processes of building environmental certification. This demand is growing, requiring changes in how the agents involved in the project perform their activities. This work aims to identify the effects of the environmental sustainability demand for building design as from an environmental certification process. For this purpose, a literature review was carried out of the environmental sustainability demand and the design stage of buildings. Furthermore, an exploratory research was carried out involving an environmental sustainability consulting firm and two design firms – an architectural firm and an MEP firm (Mechanical Electrical Plumbing) – in the city of São Paulo. These firms participated in a project comprising three commercial towers, certified in the program stage and in the conception stage by the AQUA Process. The AQUA Process is an evaluation and certification methodology of sustainable buildings of French origin utilized in Brazil. The techniques used to collect data were semi-structured interview and questionnaire application. The questions were divided into two blocks: the first block with general questions about the demand of environmental sustainability and the second block with questions about the project and its design process. Thus, the effects of the demand were identified as: the participation of the consulting firm in the project team; the participation of new agents; changes in contractual requirements for design professionals; the inclusion of environmental requirements in the design stage of the AQUA Process; the use of new technologies incorporated in the building and design stage; and the appreciation of the design stage and integration among the several design disciplines.

Keywords: design stage, environmental sustainability, building, sustainable requirements, market demand.

1. Introduction

The Civil Construction section is considered strategic for sustainable development since it is responsible for the consumption of most natural resources. It also has a detachable economic role considering its contribution to GDP (Gross Domestic Product), and employs a considerable number of workers, besides satisfying the basic human needs of housing, health and leisure (SILVA, 2003; FIGUEIREDO, 2009).

Considering the Buildings subsection and particularly the environmental dimension of sustainable development, it is possible to observe that products from this subsection have an impact on the environment, consuming resources and generating waste throughout their life cycle. For example, the impact occurs in the materials extraction needed for production of the buildings during the production stage, due to the interference in the environment; of the handling of materials and building components, in the stages of use, operation, maintenance and demolition, due to electricity and water consumption, solid waste and gases emission (DEGANI, 2003; KIBERT, 2007).

In this context, the importance of the design stage is evidenced. This stage has a high influence on the quality and performance of the final product, so it can be a strategic stage to adopt environmental impact mitigating solutions. The demand for more sustainable buildings is growing, requiring an improvement in how the agents involved in the project perform their jobs.

As the design process grows in importance and complexity, there is an urgent need for an integrated approach requiring, among other things, a participatory co-engineering among designers, engineers and manufacturers, as well as the development of advanced design tools. It is advisable to use information technology in the integrated design models in order to obtain a continuous flow of information during the design life cycle, allowing for continuous cycles of information feedback. This will enable all the participants to work jointly, exchanging information about the design and the use of design tools to optimize the design and construction process (WEINSTOCK, WEINSTOCK, 2000).

The aim of this work is to identify the effects of the demand of environmental sustainability from an environmental certification process on the building design stage.

2. Research Methodology

The research methodology used was the exploratory research. According to Gil (2008), this type of research provides to the researcher more familiarity with the problem studied, making the problem more explicit and allowing the formation of hypotheses. The main purpose of exploratory research is to allow ideas to be improved or insights to be had. The planning for data collection is very flexible, making possible to consider various aspects related to the fact studied.

The research conducted involved a consulting firm in environmental sustainability and two design firms – an architectural firm and an MEP firm (Mechanical Electrical Plumbing) – in the city of São Paulo. These firms participated in a project involving three commercial towers, certified in the program stage and in the conception stage by the AQUA Process.

For data collection, semi-structured interview and the application of a questionnaire were used. The questions were divided into two blocks: the first one with general questions about the demand for environmental sustainability and the second with questions about the project and its design process.

Two interviews were conducted with the technical director of the consulting firm. Additionally, we consulted the project data considering their characteristics and the studies focused on environmental sustainability actions conducted by the firm. An interview was conducted with one of the general directors of the MEP firm. The questionnaire was answered by the detailing design technical director of the architectural firm, via e-mail.

A literature review of the environmental sustainability demand and the design stage of buildings – the main subjects of this work – was carried out.

3. The Demand for Environmental Sustainability and the Design Stage

Several factors determine the quality of the building design. According to Picchi (1993), quality can be broken down into: quality of the project program, quality of the design solutions, quality of the design presentation and quality of the drafting process or the design service.

The design decisions should be directed to the different components of quality. For the purposes of this work, the design decisions directed to the environmental sustainability should consider the environmental requirements of the project. According to Salgado and Marques (2007), the aspects related to the environmental impact of the proposed solutions, the materials used, the waste generated in the construction process, the devices to reduce energy and water consumption in the production and the devices incorporated into the building, among others, are added to the criteria of design quality evaluation.

The design stage has an important role in the environmental sustainability context. Designers should adopt a preventive attitude during the design process, focusing on the specifications of materials to be used, the indoor air

quality in the use stage of the buildings, the health of the occupants, the influence of the location of the building, the characterization of the lighting systems, air conditioning and water heating (DEGANI; CARDOSO, 2002). Thus, there are new design constraints that consider the relation between building and the environment (MONTES, 2005). There is a growing demand for more sustainable buildings, with an increase in common requests by design clients which include sustainability concerns for economic and/ or environmental reasons. This requires an improvement from work performance of the design professional in order to comply with the new requirements (CARRINHO, VANZIN e ULBRICHT, 2009).

In recent years, it is increasingly common to find designers who have developed expertise in the environmental field usually along with consultants and experts. The environmental consultants have been requested directly by the client or on the recommendation of the design team (GANGEMI, MALANGA e RANZO, 2000).

Many clients ask designers for "green buildings". However, they do not always give a formal briefing with clear environmental objectives to the design professionals. The briefing is often a simple schedule leaving out the definition of the client requirements. Thus, it is important for the design team and their consultants to adopt a proactive attitude to include alternative solutions to the design toward the environmental quality of the building (GANGEMI, MALANGA e RANZO, 2000).

According to REED (2005), the client should select design teams (or green building experts) with expertise in integrated design and process design to optimize systems in a cost-effective manner. According to the author, it is more important for the design team to be willing to learn new ways of looking at the systems and to change their design process than green expertise itself. According to Kibert (2007), considering sustainable construction, it has been demonstrated that integrated design produces higher quality buildings as compared to conventional relationships of design with precisely the same green briefing for a project. Although some authors use the term "integrated design", it is important to note its similarity to the concept of "concurrent design", present in the work by Melhado (2001) and Fabricio (2002).

According to Felix (2008):

- the design process has required the performance of a larger number of consultants due to the wide use of alternative systems related to both energy and water use;
- the design process has also required the presence of a consultant in sustainable buildings; among other factors, these professionals act providing a holistic view to the design process;
- the design process has been demonstrated as a differentiated process due to its multidisciplinary nature and great interaction within the design team.

Along with the demand for more sustainable buildings and changes in the design process, modern tools such as BIM (Building Information Modeling) and support tools have received attention in relation to the search for improvements in communication and collaboration design process, and the integration of design solutions providing a systemic view to the professionals involved. According to Azhar et al. (2011), sustainable design strategies and BIM combined have the potential to change traditional practice design and to produce a high performance facility design. For sustainable building, designers have to carry out in-depth analysis of sustainability related to the building form, materials and components, MEP systems, energy and water consumption, among others. BIM allows multidisciplinary information to be superimposed on a model and the designers can carry out these analyses accurately and efficiently.

According to Korkmaz et al. (2010), to facilitate the work of the design professionals, a design process model can be used with the key components of the process in order to improve its execution for buildings with sustainable requirements. Additionally, the integrated use of visualization tools, such as tools for energy and daylighting simulations, can facilitate interaction among designers from different disciplines by improvements in the communication.

The following issues are related to this work but they were treated superficially during data collection due to its cutting theme – the demand for environmental sustainability and the design stage. These issues can be explored in a future work using another research method in greater depth. They are:

- Building environmental assessment systems, such as LEED (Leadership in Energy and Environmental Design) and AQUA Process (High Environmental Quality of Buildings). AQUA Process is an evaluation and certification methodology of sustainable buildings of French origin utilized in Brazil;
- Performance Standard for residential buildings up to five floors (ABNT NBR 15.575) in force since 2008 in Brazil which must be complied with by AEC firms (Architecture, Engineering and Construction) in 2012;
- Procel Edifica (National Program of Energy Efficiency in Buildings) launched in 2003 in Brazil which must be complied with by AEC firms in 2012. Procel Edifica is a label that indicates the energy efficiency of the building;
- BIM and simulation tools in promoting environmental sustainability in buildings

4. Exploratory Research

4.1. Characteristics of the Firms Studied

The following characteristics were obtained through interviews, use of questionnaire and firm websites.

The consultant firm studied provides sustainable solutions for the design, execution and operation stages of new and existing buildings. It also assists real estate developers in the coordination of the designs and construction management, integrating sustainability concepts to everything involved in the project.

The firm offers the following services: assistance in LEED environmental certification; energy efficiency consulting; commissioning of energy systems; assistance in the environmental AQUA Process certification; consultancy and studies of bioclimatic architecture; consultancy for energy efficiency Procel Edifica labeling; implementation and follow-up of management systems concerning health, safety and environment in construction; implementation and energy management system follow-up in real estate development firms, construction firms, shopping centers and retail firms (shops, supermarkets and banks); assistance in BREEAM (Building Research Establishment's Environmental Assessment Method) environmental certification; consultancy for managing greenhouse gas emissions.

The firm has been in the market for 4 years providing service to the segments of commercial and residential buildings, shopping centers, industrial buildings, and public and private buildings. Most works are inserted into segments of commercial buildings and shopping centers; the demand for residential buildings is at the beginning. The firm has 20 employees, around 50 works already undertaken and 25 works in progress. The structure of the firm consists of a technical director, three design managers and coordinators who work in different design disciplines, such as air-conditioning, electrical, architecture, hydraulics and bioclimatic comfort. The firm stands out for having a team focused on efficiency analysis that strongly support all designs. In addition, there is a team focused on the integration of the construction sustainable requirements. Most of the contracts involve design and construction; in this case, the firm follows the project from the beginning to the end with the delivery of the building.

The architectural firm has been in the real estate market for 4 years focusing on AA buildings. It has 30 members, around 50 works already undertaken and 15 works in progress. The firm has creation, feasibility study and detailing design teams, and it also has an administrative area.

The MEP firm offers design services and consultancy in the area of hydraulic, electrical, cooling and air conditioning, commercial and industrial refrigeration, safety and automation, hospitals, industrial and building automation systems, among others. In addition, it also offers construction inspection and monitoring services. The MEP firm has been in the market for 25 years providing services to the commercial and residential buildings, shopping centers and industrial buildings segments. It has 50 employees, around 1,320 works already undertaken and 80 in progress, considering the following service stages: initial, ongoing and construction stage (final). The structure of the firm consists of the sectors: administrative, commercial and technical – the administrative sector supports the other two. The technical and commercial ones are the responsibility of two directors, the director responsible for a particular design is also responsible for commercial relationship.

4.2. General Questions about the Demand of Environmental Sustainability and the Design Stage

The interviews and questionnaire data allowed obtaining a set of considerations that are summarized as follows.

4.2.1. Considerations about the Clients of the Studied Firms

The consulting firm was founded due to the demand for environmental sustainability from real estate developers who are clients with an interest in inserting sustainable requirements in their projects. Three types of client, to whom the firm provides services, can be considered: (1) the client who wishes to obtain the environmental certification for the building for commercial reasons and does not have well defined goals; (2) the client who has no concern with the certification itself since he will occupy or operate the building, but who is concerned with operating costs; (3) and the client who wants to associate environmental sustainability to the firm image.

According to the architect interviewed, observing the real estate market, sustainability is seen as marketing or as cost saving in the long term, and is linked to individual interests and not to planetary interests.

The MEP firm professionals have been asked by clients about their knowledge related to the environmental certification processes and their work experience related to the buildings certified. According to the director of the MEP firm, during the development of the project, clients want solutions that increase the value of the building since the cost is not too high. The types of clients mentioned by the respondent, similarly to those mentioned by the director of the consulting firm, were as follows: (1) the client who wishes to obtain environmental certification and the concept of environmental sustainability is incorporated into his firm; (2) the client who is not interested in the certification itself but he wants to insert the environmental requirements to the building since he is concerned with the building operating costs; (3) and the client who intends to obtain the environmental certification of the building due to its evidence in the market; sustainable requirements will not necessarily be considered in the next buildings.

4.2.2. Considerations about Environmental Sustainability of Buildings

According to the consulting firm director, it is possible to produce changes in the profile of design professionals. The professionals who had presented barriers related to the insertion of environmental requirements in the design changed their behavior into a positive attitude, believing that their firms must be prepared to meet the new market demands.

The activities of the consulting firm studied refer to the analysis of the impact of design solutions, the management and coordination of the design focused on environmental sustainability. Therefore, the consultant guides the stakeholders in the incorporation of environmental requirements, promoting systemic view of design solutions.

For example, if the stakeholders discuss the use of a high-performance glass in the building as a single solution, the consideration of the high product cost will probably be a decisive factor not to use it. On the other hand, if they discuss the use of the glass from a systemic perspective, they will probably consider the solution impacts, such as the use of the glass providing savings in the air conditioning system.

In this context, we highlight the importance of design coordination towards environmental sustainability and integrated design. For a long time, according to the consulting firm director, the Buildings subsection focused on unsuited designs; many concepts learned by design professionals were lost for a lack of market demand. Nowadays, with the demand for sustainability, there is a demand for integrated solutions that consider the life cycle of the product and the reconsideration of the concerns, for example, with building orientation, daylighting, among others. Additionally, there is the use of new technologies both in the building as in the design development.

According to the architect interviewed, the AQUA Process or LEED environmental requirements represent the correct way to design, considering the urban environment, the site, the users' life quality, etc.

According to the director of the MEP firm, environmental sustainability is a global trend. Larger firms embrace the cause first and the others must follow; otherwise they are off the market.

4.2.3. Considerations about Performance Standard for residential buildings up to five floors (ABNT NBR 15.575) and Procel Edifica

Considering the issues related to environmental sustainability, the consulting firm's clients have not mentioned the Performance Standard for residential buildings up to five floors (ABNT NBR15575). Nevertheless, the consulting firm's team adopts some acoustic criteria from that standard in its work. Clients mention Procel Edifica but they have little knowledge about the requirements. According to section 3 herein, the standard and Procel Edifica must be complied with by AEC firms in 2012, thus they must be prepared.

The architectural firm has followed the evolution of the standard, but according to the respondent, the information about products performance to be used by architects has to come from suppliers. The company had no contact with PROCEL so far.

The MEP firm's professionals have received an alert from clients about the need of meeting the performance standard. The interviewee does not have deep knowledge on the standard, but he said that the difficulty in adapting is very low. The firm had two client requests related to Procel Edifica and the firm's professionals sought information about the label, but they did not find objective information related to the way to meet them. The designs are being developed as usual without label consideration.

4.2.4. Considerations about BIM

According to the consulting firm director, large design firms are moving towards the use of BIM. The consulting firm works with the energy, thermal comfort and daylighting simulations software compatible with BIM tools. The consultant worked with a design in Revit Architecture software developed by an architect and he was responsible for conducting the energy simulation in EnergyPlus. The design in Revit facilitated the simulation process.

The architect did not mention BIM.

The MEP firm has made investments in hardware and software. Revit MEP has been used (BIM tool for mechanical, electrical and plumbing systems) and two designs are being developed in this software but also in CAD to meet the construction demand. According to the interviewee, other design specialties are advanced in relation to the use of BIM, and that in four years all the professionals will be working with BIM tools.

4.3. Questions about the Project Case

The interviews and questionnaire data allowed obtaining a set of considerations about a project case summarized as follows.

4.3.1. Characteristics and project team

The design is composed of three commercial towers, more than 189,000 m² of built area and 77,289.50 m² of total area of private offices (3 towers). One of the towers has 30 floors and the other two towers around 25 floors. The project was certified in the program and design stages of the AQUA process, but it was not evaluated in the execution stage. The project team was composed of the following agents: real estate developer, construction firm, design firms and consulting firm. Both the real estate developer and the construction firm have design and construction teams, and the developer has a sustainability manager in its staff.

4.3.2. Considerations about the project development

The project planning began with a focus on environmental sustainability so as to obtain LEED environmental certification of buildings. LEED was chosen by the real estate developer and the design firms did not participate in the definition of the project environmental objectives.

However, the choice of the environmental certification was changed after the pre-design stage. The real estate developer opted for the AQUA Process certification and the consulting firm was hired at the beginning of the detailing design.

According to Rodrigo (2011)¹, the choice of the real estate developer was based on a comparison between LEED and the AQUA Process. AQUA Process was chosen due to the developer's contact with the certification body, and also due to learning issued from the audits. In addition, AQUA Process is more flexible in relation to the adaptation to the local context than LEED; there were difficulties with the LEED criteria which are not adapted to the Brazilian reality, especially in relation to energy.

According to the consulting firm director, there was some resistance from designers regarding the modification of the environmental assessment system because of the time required for the changes, since many design decisions had already been taken.

The stakeholders (real estate developer, construction firm and design firms) attended meetings with the consultant that evaluated the designs in order to analyze if the environmental requirements were being considered and he requested changes in the designs. The designers realized that the changes were not very hard to implement since the project had environmental requirements from the beginning of its life cycle.

According to the architect interviewed, there were few contract changes and some MEP design changes interfered with the architectural design.

According to the MEP firm director, there was a process change and consequently an increase in design work. The firm's professionals did not know the AQUA Process and the real estate developer was not acquainted with the certification, which meant joint learning. According to the interviewee, there were no contractual and price changes in the design.

Two new agents were hired along with the consulting firm: an acoustic consultant and a sanitary engineer. The sanitary engineer was responsible for the use and waste operation design of the buildings.

The design coordination was carried out by the real estate developer up to the pre-design stage and by the construction firm during the detailing design. The construction firm also solved the incompatibilities among the different designs during the detailing design.

Before signing the contract, the construction firm's professionals received the document Sustainability Guidelines for Construction Firms prepared by the real estate developer and by the consulting firm. Therefore, the construction firm was aware of the skills needed to meet the requirements of those Guidelines. On the other hand, the design firms were focused only on the contract scope.

The interaction of the project team occurred in the design meetings in the real estate developer firm or construction firm with the participation of the designers. There was a matrix of responsibilities (sustainable requirements X agents) focused on certification in order to define the specific agents that should attend each meeting and the team had the support of a collaborative environment for information exchange.

According to the architect interviewed, the designers had to attend the meetings to align design issues and they also had to prepare reports for the consultants who subsequently emitted feedback to design firms individually or together, as required. According to the MEP firm's director, questionnaires related to the environmental certification were answered and forwarded to the consultants.

Regarding the insertion of the environmental requirements in the project, the consultant understood the purpose of the real estate developer and carried out a diagnosis related to the environmental requirements to be worked out and presented it to the client. Upon the client's approval, the environmental profile of the project was defined and the environmental priorities identified were: relation of the building with the environment, construction site with low environmental impact, energy management, water management, waste management of

¹ Rodrigo (2011) interviewed the project director and the real estate manager these agents were not interviewed in this study.

building use and operation, maintenance (permanence of environmental performance), hygrothermal and visual comfort.

The environmental knowledge of the consultant, designers and construction firm's professionals was necessary to achieve the priorities – thus, the importance of the selection of these agents should be highlighted. The consultant conducted several environmental studies: analysis of the building site location, environmental briefing, study of solar exposure impact, luminosity and views, design of operation waste management of the building, daylighting simulation, thermal and energy performance.

The environmental studies were performed after the pre-design stage when many design decisions had already been taken. This is a special case because there was a change in the type of environmental certification intended. However, some authors² suggest that these studies be conducted in the early stages of the design and also later; the simulation models evolve in information throughout the design process facilitating decision-making.

According to Rodrigo (2011), the architect mentioned that no new competence was developed in the architecture firm because the real estate developer (client) requested the assistance of specialists whenever necessary. According to the MEP firm's director, new knowledge was not necessary for this project. However, the director made clear to other agents which his work scope was and the activities that were his responsibility. According to the interviewee, if the firm has the knowledge required, some additional environmental activities are easy to perform. If not, the knowledge needs to be acquired since these activities cannot be carried out in "normal" projects without the demand for environmental sustainability.

5. Results and Discussion

The identification of the effects of the demand for environmental sustainability for the building design, the aim of this work, was based on the literature review and exploratory research. Although the effects have been identified, other studies with a research method in greater depth are required to corroborate the results of this work. The research method utilized in this work was the exploratory research. According to Gil (2008), the exploratory research provides to the researcher more familiarity with the problem studied, making the problem more explicit and allowing the formation of hypotheses. The main purpose of exploratory research is to allow ideas to be improved or insights to be had.

A result of the demand is the participation of the consultant in the project team promoting the insertion of environmental requirements in the design stage. Two new agents were hired along with the consulting firm: an acoustic consultant and a sanitary engineer. It corroborates Gangemi, Malanga and Ranzo (2000) and Felix (2008) in relation to the participation of consultants in the design process. The role of the consulting firm is to assist the clients in defining their goals and the environmental profile of the project.

Among the types of clients mentioned by the professionals interviewed, there is the client who wishes to obtain the building environmental certification for commercial reasons and does not have well defined goals – Gangemi, Malanga and Ranzo (2000) mention this type. However, there are other types of clients: the client who wishes to obtain environmental certification and the concept of environmental sustainability is incorporated into his firm; the client who has no concern with the certification itself since he will occupy or operate the building, but he is concerned with the operating costs; the client who wants to associate environmental sustainability to the image of the firm; and the client who intends to obtain the building environmental certification due to its evidence in the market; sustainable requirements will not necessarily be considered for the next buildings.

Another effect of the demand refers to changes in contract requirements. From the very beginning of the service request, designers should be aware that there are sustainable requirements in the project and they have to meet the requirements in their designs. The insertion of environmental requirements is also a demand effect. The design should be coordinated focusing on environmental sustainability and evaluated in relation to the compliance with sustainable requirements. Several authors mention new design constraints that consider the relation between buildings and the environment, such as Salgado and Marques (2007), Degani and Cardoso (2002). Additionally, new activities related to this effect gain prominence, such as the commissioning process, service provided by the consulting firm, that ensures the proper functioning of the systems.

As a result of the demand, there is the use of new technologies, both incorporated in buildings and in the design stage. Azhar et al. (2011) and Korkmaz et al. (2010) mention the use of BIM and visualization tools, respectively. According to the exploratory research, there are new tools being used, such as tools for energy and daylighting simulations, among others. In addition, design firms are acting towards the implementation of BIM tools. The consulting firm had an experience with a design developed by Revit Architecture which facilitated the process of energy simulation and the MEP firm's designers are using Revit MEP.

Kibert (2007) and Felix (2008) highlight the importance of integrated design for the project that has to comply with sustainable requirements. According to the director of the consulting firm, real estate developers have realized that when there is integration, it is possible to reduce overall costs and to obtain better design solutions. According to the MEP firm's director, there are more agents in the project team of the sustainable projects and there is also more interaction within the team.

² Martins (2011); Crosbie, Dawood e Dawood (2011).

6. Concluding Remarks

Professionals, especially design ones, are experiencing an opportunity era. Design is appreciated since most of the environmental requirements are related to the decision-making in the design stage and there is the reconsideration of the concerns (“good design concepts”), for example, with building orientation, daylighting, among others. These aspects contribute to the good performance of the building. Although detailed studies are required to corroborate the following conclusions, it is possible to imply that the professionals are also being challenged since:

- the design process is not defined, there is a lot of rework in the design tasks;
- the scope of the agents involved in the project is not defined. What are the responsibilities of each agent and the scope of the designers?
- should new competences be developed according to the demand for environmental sustainability? The design professionals interviewed mentioned that new competences were not developed, but they did not realize that they had developed new competences upon learning about the AQUA Process. Additionally, the designers did not realize that it is possible to incorporate new knowledge brought by the environmental consultant;
- the time of the use of simulation tools and their results should be defined to facilitate decision-making in the design process;
- the current demands and their interrelation should be considered in the design process – environmental certification, Procel Edifica label, Performance Standard and BIM. Procel Edifica label and Performance Standard seem little considered by the professionals interviewed.

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