

Management and environmental sustainability – guidelines for architectural and engineering design firms

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Abstract

Purpose – The objective of this paper is to draw up management guidelines on environmental sustainability for architectural and engineering design firms.

Design/methodology/approach – The paper is derived from a research experience between 2010 and 2018. That experience comes from three source sets: Management Development Program for Design Firms from the Research Line of Management Design, Department of Civil Construction Engineering, University of São Paulo in Brazil; papers including a doctoral thesis; and literature review. Revisiting and investigating processes were conducted by research questions, resulting in lessons learned, management difficulties and guidelines.

Findings – The guidelines were drawn up from a strategic sphere, understanding internal and external factors to the firm, diagnosis of the firm's management and sustainability, a building sustainability plan, implications of the plan for management processes, plan monitoring and control and plan evaluation.

Research limitations/implications – The studies were mostly conducted in Brazil, and one of them in the USA. Other studies could be carried out in other countries comparing findings or implementing the guidelines.

Practical implications – The findings will provide feedback to Management Development Program for Design Firms (PDGEP) in the action research method. Moreover, the knowledge about firm's capabilities can advance understanding of architectural and engineering (AE) design firm management as support for sustainability, performance and building information modeling (BIM).

Originality/value – Architectural and engineering design firms are hardly discussed; design is treated in the building project context, giving prominence to technical solutions, not to management ones.

Keywords Design firm, Design office, Management process, Sustainable design, Sustainable construction, Small and medium-sized enterprise

Paper type Research paper

1. Introduction

Sustainability has been discussed worldwide, and civil construction plays a relevant role for achieving its goals. Incentive policies, government regulations, reduction of the environmental impact, energy and water efficiency, users' health and comfort, client demands, sustainability awareness, firm reputation, corporate social responsibility, commercial value and marketability, project team's knowledge and skills and management support are pointed as drivers of environmental practices in buildings (Darko *et al.*, 2017; Oke *et al.*, 2019; Ahmad *et al.*, 2018; Li *et al.*, 2019; Wang *et al.*, 2018; Zhang *et al.*, 2019).

However, barriers are found for implementing sustainability in the civil construction industry (Chan *et al.*, 2018; Daniel *et al.*, 2018; Darko *et al.*, 2018; Agyekum *et al.*, 2019; Martek *et al.*, 2019; Opoku *et al.*, 2019; Pham *et al.*, 2019; Hikmat and Alkayed, 2019). Some barriers for



sustainable building design are related to management, such as interpretation of the client requirements as design criteria, integrated design methods, knowledge of new design solutions, methods and data for comparing solutions in terms of sustainability, information about solutions risks, “sustainability” position or team for managing sustainable designs and incentives for developing knowledge and methods (Häkkinen and Belloni, 2011). Architectural and engineering (AE) design firms’ management is essential to overcome some barriers.

Building designs have been demanded regarding sustainable requirements and have gained complexity. According to Rekola *et al.* (2012), design is essential for delivering a sustainable building that requires ability to collaboratively create innovative solutions to meet the demanding requirements. However, design is a result of efforts in planning, people, finance, business, marketing and information. Therefore, a successful sustainable design depends not only on technical solutions, but also on the management solutions adopted by AE design firms.

Small AE design firms are often composed by founding partners, a few employees and trainees. In that kind of organizational structure, the responsibilities of each one are poorly defined and usually concentrate on the partners or the most experienced employees, involved in several activities including the firm management (Souza, 2009). In many cases, partners perform designer and manager roles, which are sometimes not clear to them, especially to architects engaged in the building creative process (De Paula, 2013). Since organizational resources are essential for developing sustainable buildings, the concern of this paper is about the challenge of dealing with sustainability in that firm context.

According to Salgado (2011), a quality management system is a requirement for developing sustainable buildings through integrated design. The author found that a critical issue for achieving sustainable design goals in Brazilian and in French design firms is the implementation of a document management system.

At World Sustainable Built Environment (WSBE, 2020) conference, the implementation of the United Nations sustainable development goals and how the digitalization can support the sustainable transition of the built environment were discussed (Andersson and Eidenskog, 2020; Theißen *et al.*, 2020; Sameer *et al.*, 2020; Chan and Lam, 2020). Digitalization, particularly through building information modeling (BIM), has an enormous potential in contributing to sustainability. BIM enables the building integrated design, performance simulations, life cycle assessment and information use throughout the building life cycle.

Rekola *et al.* (2012) stated that the design coordinator contributes to the sustainable building process through the successful leadership of human creative competence. According to the authors, design coordinator practices should be further explored, but it is a challenge to describe effective ways of managing when the activities are invisible, such as facilitating the design team job. In this paper, it is argued that designers may hinder sustainable buildings processes, since they are more used for technical issues instead of thinking about a suitable organizational environment for developing successful sustainable designs.

Several authors have pointed out the relationship between management and sustainability corroborating the general topics of this paper (Salgado, 2011; Salgado *et al.*, 2012; Li *et al.*, 2014; Annunziata *et al.*, 2016; Zhang *et al.*, 2011; Qi *et al.*, 2010; Ofori-Boadu *et al.*, 2012; Opoku *et al.*, 2015; Herazo and Lizarralde, 2015; Goel *et al.*, 2019). Yet, sustainability-related guidelines are focused on project planning, design developing or post-design, not demonstrating the means of meeting the recommendations through AE design firm management (AIA, 2011; AIA, 2012; AsBEA, 2012; ASHRAE, 2006; BSRIA, 2012; BRECSU, 2000; CIBSE, 2004; CIC, 2007; RIBA, 2011; RIBA, 2013). In the conferences the author participated in, AE design firms were hardly discussed; design is treated in the building project context, giving prominence to technical solutions. Thus, the aim of this paper is to draw up management guidelines on environmental sustainability for AE design firms.

The paper is composed of five sections including this Introduction. Section 2 presents a literature review both about this paper authors' research path and other authors' research path. The research methodology is described in Section 3. Then, Section 4 shows the lessons learned by revisiting this paper authors' research production and study sources leading to the guidelines (A–F) detailed in Table 3. Finally, Section 5 presents the conclusions, limitations and suggestions for further studies.

2. Literature review

Some researchers have dedicated their studies to AE design firms' management and environmental sustainability (Salgado, 2011; De paula *et al.*, 2014; De Paula, 2016; De Paula and Melhado, 2018). Table 1 shows what should be taken into account in terms of design firms' management for promoting sustainable building.

Figure 1 demonstrates how design firms' management processes are connected for developing sustainable building design. Strategic planning and organizational structure support the whole process, while information permeates the blocks. While business and marketing and aggregate services involve client issues from requirements definition, scope and contract to sustainable design deliverables, the other management processes such as design process, finance, people and performance evaluation provide conditions (how, what, who, criteria) for the main process.

De Paula and Melhado (2018) found that design firms' management processes are demanded by sustainability in the daily work practice, requiring investment, technical knowledge, new activities and agents. However, according to the authors, sustainability has

Management process	Relating management and environmental sustainability
Strategic planning	Firms' strategic positioning in the sustainable design market in addition to the identification of strengths, weaknesses, threats and opportunities in relation to sustainable design
Organizational structure	Relation between the firm's structure and implementing sustainable design strategies, and the firm's structure and performing the work
Planning and controlling the design process	Mapping the design process considering new activities (definition of environmental objectives, detailed research of material and components, energy simulation, commissioning, certification documentation, etc.), agents (consultants and specialists) and tools (software and checklist)
Aggregate services	Activities of sustainable design delivery, site visits and post-occupation evaluation
Financial management	Sustainable design costing and pricing (working hours, specialists). Considering not only risks, but also investments (in people and in technology)
Business management and marketing	Technical and commercial proposals that enable meeting the environmental objectives, contractual models that stimulate an integrated design process and contractual elements taking into account sustainable design scope in addition to the analysis between client requirements and the firm's resources and capabilities regarding sustainable design
Information system	Managing environmental objectives and requirements, internal and external communication and design data collection
People management	Professional profile, competence and training in sustainability, responsibility matrix and suitable remuneration
Performance evaluation	Analysis between sustainable design and client's requirements, sustainable design and environmental objectives and sustainable design and project program. Indicators

Table 1.
AE design firms' management for promoting sustainable building

Note(s): (De Paula *et al.*, 2014)

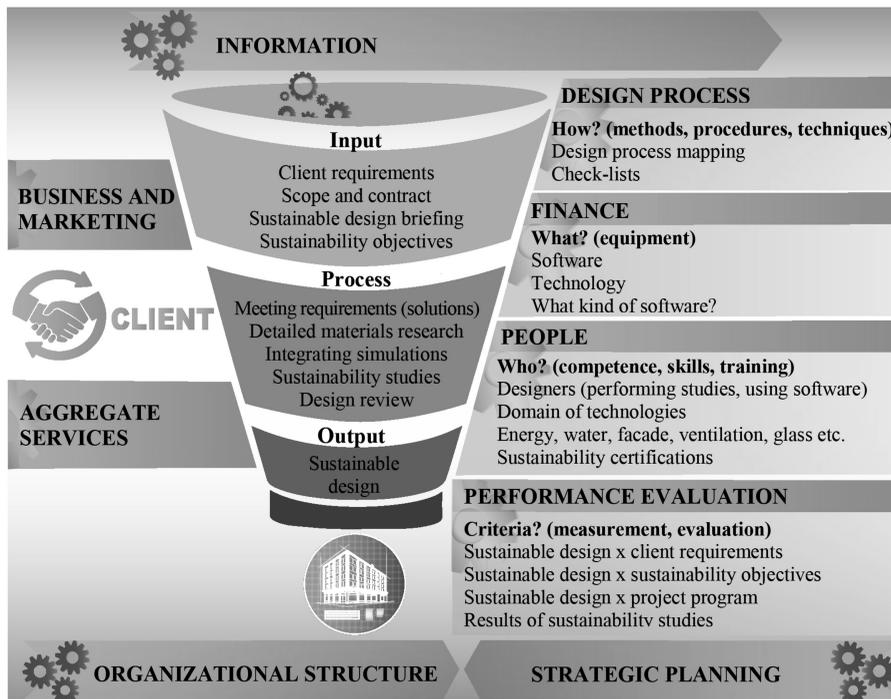


Figure 1. Connecting management processes for developing sustainable design

not been fully taken into account in all management processes albeit it is critical in the firm strategic spheres. Despite being responsible for guiding clients in relation to environmental sustainability, this responsibility is not necessarily recognized in the design firms' business development (Murtagh *et al.*, 2016a).

Salgado *et al.* (2012) analyzed the influence of environmental sustainability on practices of architectural design, consulting and construction companies from France. Management information was highlighted by interviewees as essential for developing projects with sustainable requirements. Li *et al.* (2014) identified experience and knowledge in green building, an organizational green culture and innovation capability as the most important factors in projects with environmental objectives for achieving higher ratings in Green Mark, a certification system utilized in Singapore. Also in Singapore, Li *et al.* (2011) found relevant groups of factors for delivering green building projects: human resources, technical and innovation-oriented factors, support from designers and senior management, project manager's competence and coordination of designers and contractors. In Italy, Annunziata *et al.* (2016) identified the following pertinent factors for achieving sustainability objectives: clear environmental goals, collaboration with the supply chain, education and training and use of appropriate management tools.

Other authors have conducted research about critical success factors for green building projects (Li *et al.*, 2019; Sang and Yao, 2019; Shan *et al.*, 2020; Shen *et al.*, 2017, 2020; Zhang *et al.*, 2017), such as owner's commitment, clear goals, project characteristics, external environment (sociopolitical and economic environment), project management, integration of the project team (communication and cooperation), project manager's skills, competence of the project participants, involvement of knowledgeable experts, technical and management innovation and enterprise capability.

Ofori-Boadu *et al.* (2012) explored the management practices of contractors necessary to achieve a successful implementation of Leadership in Energy and Environmental Design (LEED) projects. The findings support the following criteria in the implementation of sustainability: leadership, strategic planning, customer focus, measurement, analysis and knowledge management, workforce focus and operation focus.

Sustainability is addressed differently by project stakeholders causing tensions among them (Herazo and Lizarralde, 2016). Architectural design firms have extrinsic motivations for developing sustainable design, such as client demand and regulation, besides autonomous and self-determined motivations (Murtagh *et al.*, 2016b).

According to De Paula *et al.* (2017), design, consulting, construction and facility management firms from the US agree about (1) including sustainable projects in the firm's strategic planning, (2) profit margins not being higher comparing sustainable projects and "traditional projects" and (3) preferring candidates knowledgeable about sustainable projects in the hiring process. Meanwhile, the authors found statistically significant differences among firms' opinions about (1) getting new projects because of the firm's reputation in past sustainable project successes, (2) changes in the firm's agreements for sustainable projects compared to "traditional projects" and (3) employing a professional that holds a distinct "sustainability" position.

Research on green buildings has increased over the years (Wuni *et al.*, 2019; Li *et al.*, 2020). Researchers have analyzed previous publications for understanding the current situation and presenting future directions (Ahmad *et al.*, 2019; Darko and Chan, 2016; Darko *et al.*, 2019; Li *et al.*, 2017, 2019, 2020; Shan and Hwang, 2018; Shi and Liu, 2019; Wuni *et al.*, 2019; Zuo and Zhao, 2014). Ahmad *et al.* (2019) conducted a review of the studies related to success or performance outcomes of the green building development. They found competence of design consultant, lack of design firm experience and knowledge in green buildings to be factors related to design team in the research on green building development. Among the future directions, Shan and Hwang (2018) pointed out the development of a corporate sustainability rating system considering professionals, equipment, financial capability, risk management capability and past successful experiences in green buildings.

The demand for green buildings is a long-term business opportunity (Ahmad *et al.*, 2019). The present paper guidelines thus assist designers for preparing their firms in terms of management to deal with sustainability, getting ready since the opportunity is already here. Besides, designers are involved with building solutions and have the chance to consider society's environmental, social and economic concerns.

Previously, the relation between management and sustainability was demonstrated. Another relevant topic is the contribution of BIM to sustainability (Azhar *et al.*, 2011; Park *et al.*, 2012; Bynum *et al.*, 2013; Cecconi *et al.*, 2019; Lucky *et al.*, 2019; Pavan *et al.*, 2019; Wall and Hofstadler, 2019; Sameer *et al.*, 2020).

According to Kamari and Kirkegaard (2019), the integrated design and BIM highlight the early design stages and an iterative decision-making process leading to sustainable solutions. However, Andersson and Eidenskog (2020) argued that there are relevant points to be considered for obtaining BIM potential, such as communication, collaboration, knowledge transfer, different standards and competence, interdisciplinary work practices and partnering. For this reason, the organizational settings and workflows should evolve to support BIM.

BIM should be supported by the firms' management processes: financial management by investing in software and hardware, people management through training, design process management due to changes in design practices, strategic planning for monitoring BIM evolution stages, among others (De Paula, 2016).

3. Research methodology

This paper derives from a research experience between 2010 and 2018. That experience comes from three source sets: (1) Management Development Program for Design Firms (PDGEP) from the Research Line of Management Design, Department of Civil Construction Engineering, University of São Paulo in Brazil; (2) papers including a doctoral thesis; (3) literature review (Figure 2).

- (1) In Brazil, PDGEP is a collaborative effort between the University of São Paulo and AE design firms. The program has six editions of experience in action research methodology implementing management models in building design firms (Souza, 2009; Souza *et al.*, 2011).

Oliveira's (2005) model is the main guide to PDGEP. According to the model, the management processes in design firms refer to strategic planning, organizational structure, financial management, people management, business management and marketing, information system, planning and control of the design process and aggregate services, and performance evaluation.

The paper's second author is the professor in charge of PDGEP, and the first author coordinated the program from 2010 to 2012. The management foundation of her research came from that period developing the following papers: Francischetti *et al.* (2011a), Francischetti *et al.* (2011b), Souza *et al.* (2011), Novaski *et al.* (2012), Souza *et al.* (2013), De Paula *et al.* (2013).

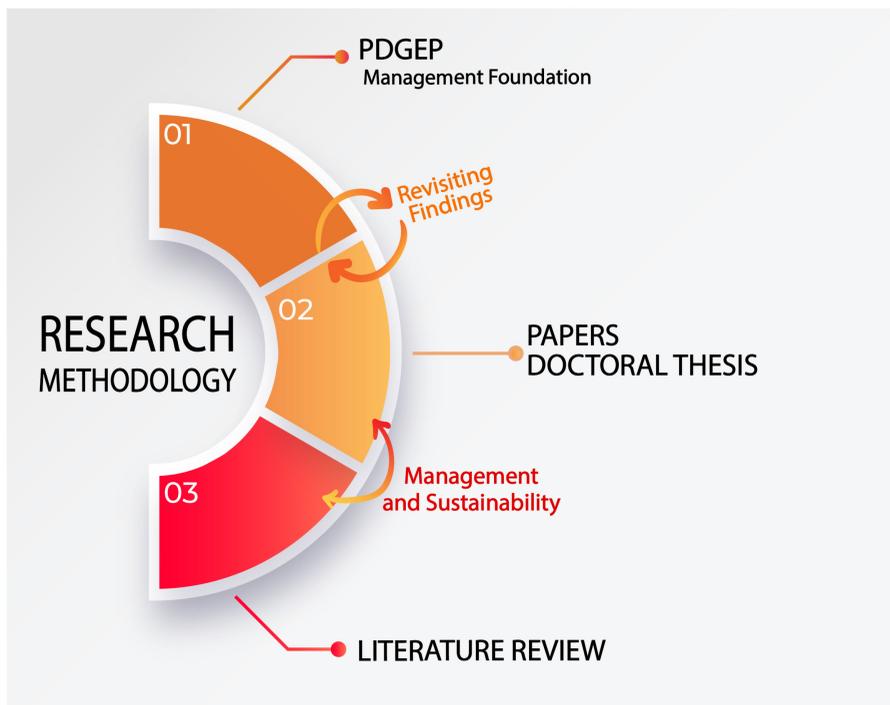


Figure 2.
Research methodology

- (2) Linking management and sustainability, the research moved forward: [De Paula and Melhado \(2012\)](#), [De Paula et al. \(2013\)](#), [De Paula et al. \(2013\)](#), [De Paula et al. \(2014\)](#), [De Paula \(2016\)](#), [De Paula et al. \(2017\)](#), [De Paula and Melhado \(2018\)](#).
- (3) A literature review was also conducted linking management and sustainability providing other authors' views.

Findings were brought to the present paper in a more mature and meaningful perspective revisiting (1) and (2), and investigating (3); see [Figure 2](#). The revisiting and investigating processes were guided by the following questions:

- (1) What has been learned from our academic production about AE design firm's management and sustainability? (It is about the research path; lessons learned are presented in [Section 4](#), see [Figure 3](#));
- (2) What are the firms' management difficulties affecting the development of building sustainable designs? (Firm management difficulties and sustainability are shown in [Table 2](#));
- (3) Building design firms play an important role in achieving the building's sustainability goals since decisions are made at the design stage. In addition, designers can influence clients and stakeholders in the development of sustainable designs. How could that research experience help AE design firms to fulfill this role through firm management support? (Guidelines are presented in [Table 3](#); see [Figure 4](#)).

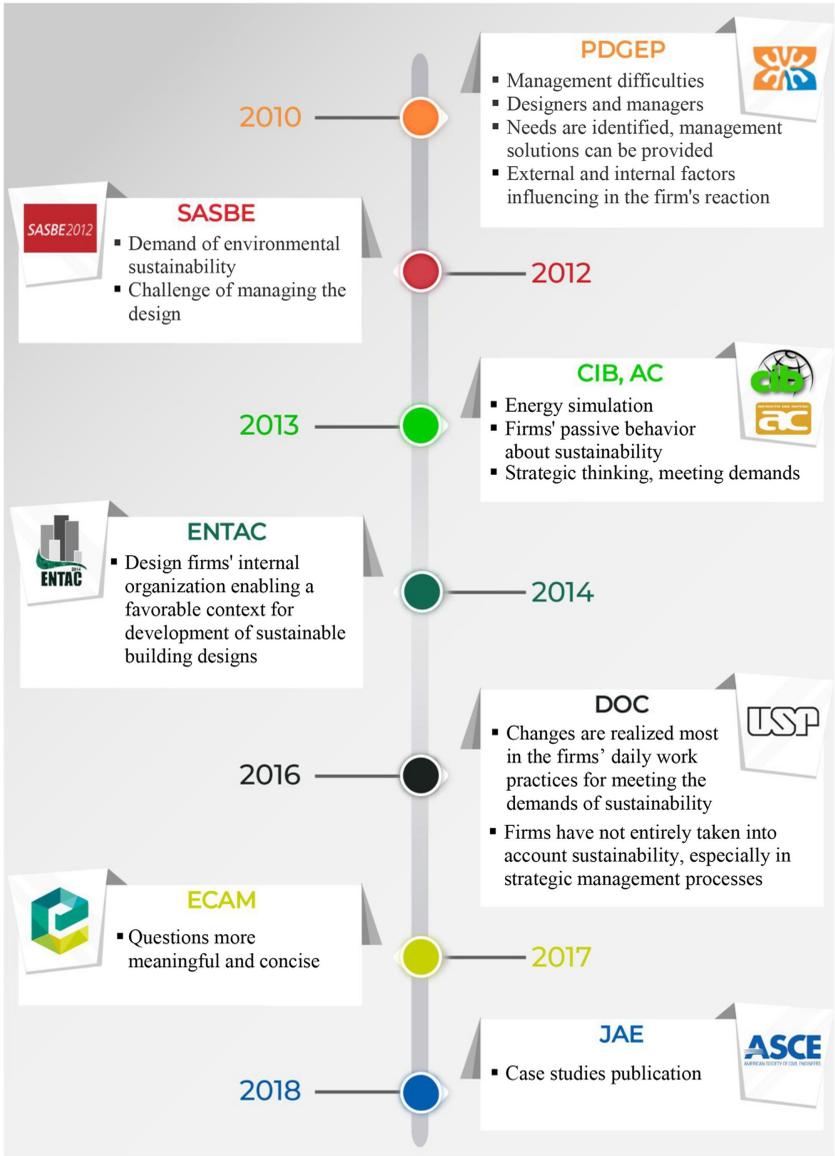
The research methods employed in the research experience were action research, exploratory research, literature review, case study and survey. The research tools were interviews, questionnaire and document analysis. Those methods and tools were detailed in each published paper and the doctoral thesis. In the present paper, revisiting and investigating processes were conducted by research questions resulting in lessons learned, management difficulties and guidelines.

4. Findings, discussion and guidelines

A number of lessons learned have been acquired from the research experience as discussed below and summarized in [Figure 3](#). Also, the lessons are part of [Table 2](#), leading to the guidelines.

From PDGEP (Francischetti et al., 2011a; Francischetti et al., 2011b; Souza et al., 2011; Novaski et al., 2012; Souza et al., 2013; De Paula et al., 2013): It was found that AE design firms have management difficulties. Since a firm's needs are identified, management solutions can be provided and the firm can improve gradually to a more mature management system. In different cases, performing the roles of designers and managers is a challenge for the firm partners; hence, arranging or delegating both positions activities is recommended to achieve a robust system. Besides, there are external and internal factors influencing a firm's reaction to the market or society demands. Preparing firms in terms of management to deal with changes and factors should be a concern in their strategic sphere.

From De Paula and Melhado (2012), SASBE: Effects of the environmental sustainability demand on the building design stage were identified: participation of new agents such as the sustainability certification consultant, changes in the design contractual agreements, inclusion of environmental requirements, use of new technologies related both to building solutions and design activity, recognition of the design stage and integrated design. It was rather surprising to find the interviewees were not realizing the challenge of managing the design with environmental sustainability demands related to design process definition,



Key: PDGEP – Management Development Program for Design Firms; SASBE – International Conference on Smart and Sustainable Built Environments; CIB – CIB World Building Congress; AC – Built Environment, Brazilian Journal; ENTAC – National Conference of Built Environment Technology; DOC – Doctorate; USP – University of São Paulo; ECAM – Engineering Construction and Architectural Management; JAE – Journal of Architectural Engineering

Figure 3.
Lessons learned

Table 2.
Study sources and findings

Study sources	Main findings	Firm management difficulties and sustainability	Guidelines
<p>1 Francischetti <i>et al.</i> (2011a), Francischetti <i>et al.</i> (2011b), Souza <i>et al.</i> (2011), Novaski <i>et al.</i> (2012), Souza <i>et al.</i> (2013), De Paula <i>et al.</i> (2013)</p>	<p>Many design firms come under external and internal influences, not conducting a strategic analysis. Most firms act passively making sudden decisions</p>	<p>(1) Lack of strategic planning (2) Identifying the needs, planning and monitoring the actions, analyzing the results and replanning (3) Seeking and analyzing firm management evolution (4) Passivity – not taking a position in the market or analyzing work possibilities regarding sustainability, performance and BIM, if the firm is not demanded (5) Sustainability is only taken into account in the operational processes (6) Structuring a new service (7) Taking advantage of the market opportunities, for example, from BIM demand</p>	A
<p>2 <i>Justification</i> Oliveira and Melhado (2006), Salgado (2011), Salgado <i>et al.</i> (2012), Li <i>et al.</i> (2014) <i>Firm, management system</i> Oliveira (2005), Souza (2009), Arantes (1994), Bello (2001), Fuzetti <i>et al.</i> (2012), Maximiano (2000), Chiavenato (2010), Farah <i>et al.</i> (2008)</p>	<p>The firm management system is composed of processes. The management processes provide favorable conditions for developing sustainable building designs BIM contributes for achieving sustainability goals</p>	<p>(1) Informal management processes affecting sustainable designs (2) Difficulty in liking management processes and sustainability in a deliberate way understanding how the firm management can contribute to achieving sustainable designs in different spheres (3) Greater concern about sustainable technical solutions of buildings than management (4) Obtaining BIM potential since it requires communication, collaboration, knowledge transfer, different standards and competence, interdisciplinary work practices, evolution of organizational settings and workflows, partnering</p>	B
<p><i>Management and sustainability</i> De Paula <i>et al.</i> (2014), Amunziata <i>et al.</i> (2016), Zhang <i>et al.</i> (2011), Qi <i>et al.</i> (2010), Ofori-Boadu <i>et al.</i> (2012), Opoku <i>et al.</i> (2015), Herazo and Lizarralde (2015), De Paula <i>et al.</i> (2013), De Paula and Melhado (2018), De Paula (2016), De Paula <i>et al.</i> (2017)</p>	<p><i>BIM and sustainability</i> Kamari and Kirkegaard (2019), Andersson and Eidsenkov (2020)</p>		

(continued)

Study sources	Main findings	Firm management difficulties and sustainability	Guidelines	
3	<p><i>Sustainability in construction</i></p> <p>Agopyan and John (2011), Berardi (2011), McLennan (2004), Kibert (2007), Godoi (2012), Rekola <i>et al.</i> (2012), Salgado <i>et al.</i> (2016)</p> <p><i>Performance</i></p> <p>Performance standard, ABNT (2013)</p> <p><i>Sustainability guides</i></p> <p>AIA (2011), BSRIA (2012)</p> <p><i>Sustainability and design firms</i></p> <p>De Paula and Melhado (2018), De Paula (2016)</p> <p><i>BIM and sustainability</i></p> <p>Azhar <i>et al.</i> (2011), Park <i>et al.</i> (2012), Bynum <i>et al.</i> (2013), Ceconi <i>et al.</i> (2019), Lucky <i>et al.</i> (2019), Pavan <i>et al.</i> (2019), Wall and Hofstadler (2019), Sameer <i>et al.</i> (2020)</p> <p>De Paula and Melhado (2012), De Paula <i>et al.</i> (2013), De Paula and Melhado (2018), De Paula (2016)</p> <p>De Paula <i>et al.</i> (2014), De Paula <i>et al.</i> (2017)</p> <p><i>Firms' management capabilities contributes to sustainability or green buildings</i></p> <p>Salgado (2011), Salgado <i>et al.</i> (2012), Li <i>et al.</i> (2014), Li <i>et al.</i> (2011), Annunziata <i>et al.</i> (2016), Li <i>et al.</i> (2019), Sang and Yao (2019), Shan <i>et al.</i> (2020), Shen <i>et al.</i> (2020), Shen <i>et al.</i> (2017), Zhang <i>et al.</i> (2017), Ofori-Boadu <i>et al.</i> (2012), Shan and Hwang (2018)</p>	<p>Understanding terms such as sustainable building, green building, certified building, sustainability, durability, service life and performance contributes to the definition of firm's product and improvement points aligning with its strategy</p> <p>BIM contributes to sustainability and performance analysis</p>	<p>(1) Sustainability is intrinsic to design decisions and solutions</p> <p>(2) Challenge in developing sustainability and performance requirement-based designs</p> <p>(3) Not promoting sustainability activities, because the firm does not develop certified buildings</p>	C
4	<p>A more favorable context for meeting environmental requirements in building designs depends not only on technical solutions, but also on management solutions adopted by design firms</p> <p>It is essential to establish how the management processes support sustainability. That support requires organized processes</p>	<p>(1) Management processes are little explored to support sustainability</p> <p>(2) Sustainability is not included in a formal strategic planning</p> <p>(3) Changing the firm's agreements for sustainable designs</p> <p>(4) Allocating formal investment in sustainability (training, technology or software)</p> <p>(5) Taking sustainability into account in the organizational structure and people management making decisions to meet the work strategy. For example, employing a professional that holds a distinct "sustainability" position, disseminating sustainability among the people hired, training, setting hiring policies to make sure that most professionals are knowledgeable about sustainability practices</p>	D	

(continued)

Table 2.

Study sources	Main findings	Firm management difficulties and sustainability	Guidelines
<p><i>BIM and sustainability</i> Kamari and Kirkegaard (2019), Andersson and Eidenskog (2020)</p>		<p>(6) Despite recognizing there are new activities and new agents in sustainable designs, the firm does not create support management tools</p> <p>(7) Performing sustainability-related studies and analysis between design and sustainability objectives of the building</p> <p>(8) BIM should be further explored to achieve sustainability goals and performance requirements</p>	E
<p>5 <i>Firm management system</i> Oliveira (2005), Chiavenato (2010), Souza (2009), Fuzetti <i>et al.</i> (2012), Melhado (2012) De Paula <i>et al.</i> (2013), De Paula and Melhado (2018)</p>	<p>Monitoring and controlling activities are just as important as planning</p> <p>Periodic evaluation and plan review are critical, considering what was not foreseen, deciding what to do, while a full evaluation enables the continuous improvement cycle</p>	<p>(1) Informal planning, monitoring and control affecting the efficiency and efficacy of actions</p> <p>(2) Conducting a systematic follow-up of a formal strategic planning</p> <p>(1) Informal management processes not including systematic evaluations and replanning</p> <p>(2) Not concluding activities and losing motivation, because of external and internal changes, and deviations</p>	E F

Guidelines	Objectives	Working points
A Understanding external and internal factors influencing the firm's reaction to the market or to society demands	Taking a position on market, society, type of client, identity and strategy of operation and management for drawing up a BSP	<p><i>External factors: market, society and type of client</i></p> <ol style="list-style-type: none"> 1. What market context does the firm operate in? 2. How does the firm contribute to the society? 3. What type of client does the firm meet? 4. What type of building does the firm develop? 5. Is there any sustainability or BIM demand from the market, society or client? <p><i>Internal factors: identity, strategy of operation and management</i></p> <ol style="list-style-type: none"> 1. What is the firm's "DNA"? What are the firm's main characteristics? (why does the firm exist?) 2. Is the firm innovative? 3. How does the firm take a position in the market? How does the firm deal with new demands? 4. Is the firm's management formal or informal? Does it support the service efficiently and effectively? 5. If there is a demand for sustainability, certification or BIM, what is the firm's reaction? If not, should the firm take a position on it? 6. Is the firm knowledgeable about sustainability concepts, certifications or BIM?
B Diagnosing the firm's management and sustainability	Understanding the current situation of the firm's management with regard to sustainability	<ol style="list-style-type: none"> 1. Is performing sustainable design a direct result of the firm's strategic planning? 2. Compared to "traditional design," are there changes in your firm's agreements for "sustainable design"? 3. Has your firm been recently engaged in performing sustainable designs because of your firm's reputation in past sustainability successes? 4. Are profit margins higher in "sustainable design" as compared to "traditional design"? 5. Does your firm employ a professional that holds a distinct "sustainability" position? 6. When hiring professionals, does your firm require the candidate to be knowledgeable about sustainable design or BIM? 7. Is there any investment regarding sustainability or BIM (training, technology or software)? 8. Does the firm have any information management tool related to sustainability? 9. In the firm's sustainable designs, are there any new activities, agents or tools (including BIM tools) in the design process?

(continued)

Table 3. Management guidelines on environmental sustainability for AE design firms

Guidelines	Objectives	Working points
C Developing a building sustainability plan (BSP)	<p>Defining the objectives, concepts to be worked on, involved people and resources to be employed by the firm</p> <p>Aligning the BSP with the firm's strategies (item A)</p>	<p>10. Does the firm conduct studies related to sustainability? Is there any contribution from BIM?</p> <p>11. Does the firm perform any analysis between design and sustainability objectives of the building? Is there any support from BIM?</p> <p><i>Examples</i></p> <ol style="list-style-type: none"> 1. Objectives: to increase design quality and reduce or eliminate environmental impacts; consider economics and society, sustainability certification; BIM implementation or evolution; to promote sustainability through BIM use 2. Concepts: sustainability, durability, life cycle analysis, performance, integrated design, BIM 3. People and interactions: Will a leader or committee be responsible for the plan? How will the firm team be involved? Considering the people's characteristics, skills and attitudes 4. Resources: people, technology, time, work fronts, financial resources, business and marketing, management
D Identifying effects of the BSP in the firm's management processes	<p>Linking the BSP and management processes as a support for meeting environmental requirements in building designs</p>	<p><i>Strategic planning</i></p> <ol style="list-style-type: none"> 1. Defining the firm's strategic positioning in the market about sustainable and certified buildings 2. Identify strengths, weaknesses, threats and opportunities about sustainable and certified buildings 3. Liking the BSP objectives to the firm's strategic planning <p><i>Organizational structure</i></p> <p>Analyzing the firm structure and strategies implementation regarding sustainable and certified buildings, promoting the required actions</p> <p><i>Business management and marketing</i></p> <ol style="list-style-type: none"> 1. Understanding the client requirements pursuing the building environmental objectives 2. Analyzing the client requirements with regard to available resources <ul style="list-style-type: none"> • Can the firm deliver what is being requested in terms of team, competence, technology and time?

(continued)

- Does it require hiring people or external services? (Considering the required environmental studies and how people and studies will be managed)
- 3. Identifying contractual elements based on the scope of the sustainable design. If applicable, defining the scope of the sustainability certification services
- 4. Drawing up technical and commercial agreements appropriate for meeting the building environmental objectives of identifying: stakeholders (roles and responsibilities); environmental constraints of the building project; risks and opportunities

Planning and controlling the design process

1. Mapping the sustainable design process including activities, agents and tools (including BIM tools) (**Figure 1**)
 - Examples of activities: identification of the building project constraints, definition of the environmental objectives, parameters definition and compliance with environmental and performance requirements, materials and component research, new technologies research, computer simulations, performance analysis, BIM for environmental simulations, sustainability certification documentation, meetings with consultants, involvement in the commissioning activities
 - Examples of agents: consultants (on sustainability, water resource efficiency, energy efficiency, commissioning, material traceability, acoustics, etc.), BIM manager, waste manager, mechanical engineer, environmental engineer, sanitary engineer
 - Examples of tools: simulation software, BIM software, checklists of sustainability certification, academic references
2. Employing a strategy for environmental studies to perform or outsource and analyze them (considering how to manage and utilize the studies in order to obtain information and to apply it to the firm field, also considering BIM support)
 - Examples of studies: environment characteristics and conditions, mass, shadow, wind, noise pollution, daylighting, artificial lighting, natural ventilation, mechanical ventilation, acoustic performance, thermal performance, performance-based selection of materials and components, facade, frame, water saving, energy saving, waste generation in the building use and operation, landscaping, microclimate

(continued)

Guidelines	Objectives	Working points
		<ul style="list-style-type: none">3. Defining and documenting the design deliverables4. Measuring working hours
		<p><i>Aggregate services to design</i></p> <ul style="list-style-type: none">1. Systematizing the sustainable design delivery2. Monitoring the construction (visits) to maintain the projected environmental performance3. Defining the owner's responsibilities regarding building operation and maintenance4. Seeking and analyzing post-occupancy evaluation data taking the required actions
		<p><i>Financial management</i></p> <ul style="list-style-type: none">1. Investing in the sustainability or BIM field (e.g. hiring professionals, training firm employees, creating management tools, acquiring software and technology)2. Measuring sustainable design costs (working hours and consultants)3. Pricing the sustainable design
		<p><i>Information system</i></p> <ul style="list-style-type: none">1. Identifying internal and external information, such as environmental objectives, environmental requirements, sustainability reports from stakeholders2. Analyzing internal and external communication media with the design team and stakeholders3. Documenting the information
		<p><i>People management</i></p> <ul style="list-style-type: none">1. Drawing up professional profiles in order to cover sustainability and BIM identifying the required competences, attitudes and training2. Developing a responsibility assignment matrix including sustainability-related design activities3. Analyzing if a distinct "sustainability" position is required or sustainability will be disseminated among the employees4. Considering sustainable design and BIM knowledge for selecting and recruiting people

(continued)

Guidelines	Objectives	Working points
E Monitoring and controlling the BSP	Monitoring and controlling the activities to deal with deviations	<p><i>Performance evaluation</i></p> <p>1. Analyzing if the sustainable design complies with the client requirements, environmental objectives and building project program</p> <p>1. Defining a schedule (including activity, person in charge, start and end dates), the person in charge for monitoring and control, methods (techniques and tools) and follow-up meetings</p> <p>2. Keeping information and analyzing what is planned, in progress, done and canceled for conducting deviations</p>
F Evaluating the results of the BSP	Providing feedback for the BSP considering the external and internal changes and activity deviations	<p>1. Periodically evaluating the plan taking the required actions</p> <ul style="list-style-type: none"> • Evaluating and realigning objectives, concepts, people involved, resources and management processes. Considering external and internal changes (market, clients, a new business, hire, dismissal, lack of motivation and commitment, new work tool, etc.), besides activities (planned, in progress, done, canceled) and deviations • Documenting the evaluations and actions <p>2. Fully evaluating the plan outlining the next steps in a continuous improvement cycle</p> <ul style="list-style-type: none"> • Revisiting the periodic evaluations • Re-diagnosing the firm management and sustainability comparing with the previous one • Holding a lessons learned meeting • Documenting the full evaluation • Conducting clients' and partners' satisfaction assessment collecting suggestions for improvement in the BSP • Drawing up a new planning



Figure 4.
Management
guidelines on
environmental
sustainability for AE
design firms

agents scope, competences, simulation tools and emerging topics connection (certifications, Procel Edifica, performance standard and BIM).

As can be seen from the literature review (Kamari and Kirkegaard, 2019; Cecconi *et al.*, 2019; Lucky *et al.*, 2019; Pavan *et al.*, 2019; Wall and Hofstadler, 2019; Andersson and Eidenskog, 2020; Theißen *et al.*, 2020; Sameer *et al.*, 2020; Chan and Lam, 2020; WSBE, 2020), BIM is no longer an emerging topic, but a current one contributing to achieving buildings' sustainability goals and performance requirements.

From De Paula *et al.* (2013), CIB: Energy simulation has been an evidence of the sustainability certification demands, particularly from LEED. The simulations were highlighted by designers, despite not considering them as a change in the design process (new activity and agent).

Sustainability certifications encouraged the energy simulation and sustainability discussion in Brazil. According to Martek *et al.* (2019), there is an excessive focus on energy efficiency at the design stage, a holistic vision to sustainability lacking in Australia. Besides, doubts about a specific certification being suitable for different countries, differences between green building and sustainable building and the reductionist view of sustainability have been pointed out by researchers (Silva, 2003; Silva *et al.*, 2003; Agopyan and John 2011; Berardi, 2011; Salgado *et al.*, 2016; Martek *et al.*, 2019; Salgado, 2019; Darko *et al.*, 2019). This scenario led the present research to a more general concept having sustainability concerns

even when a certification is not a building project goal, but still emphasizing the importance of sustainability evidences through sustainability and performance studies.

From *De Paula et al. (2013)*, AC: Sustainability is a world concern apart from the certifications. Most design firms showed a passive behavior toward the sustainability demand. Thinking strategically is crucial for a firm to be competitive and responsible. This involves learning “who” the firm is, why it exists, if it is prepared to meet demands analyzing process changes, staff qualification, internal training and equipment, as well as partnership with clients.

Regarding environmental sustainability, the design firms from that study (*De Paula et al., 2013*) recognized that it is necessary: to reflect about the sustainability demand; to obtain knowledge about sustainability certifications, environmental requirements, climate, technologies, origin and behavior of materials and components; to seek for certified suppliers with specified products; and to face the lack of technical information and products tested. On BIM, it is necessary to plan BIM implementation; to define strategies, objectives and goals; to explore BIM software; and to link BIM implementation and the firm’ management processes (people, financial, project process, etc.). The firms pointed the difficulty in taking advantage of the market opportunities, for example, from BIM demand.

De Paula et al. (2014), ENTAC showed how the design firms’ internal organization enables a favorable context for developing sustainable building designs. The link between sustainability and management seems obvious, but it is difficult for designers to be aware about this in a practical way, understanding how the firm management can contribute to achieving sustainable designs in different spheres (*Table 1, Figure 1* brings out that connection).

The contribution of the firms’ management capabilities to sustainability or green buildings was explored in the literature review (*Salgado, 2011; Salgado et al., 2012; Li et al., 2011, 2014, 2019; Annunziata et al., 2016; Sang and Yao, 2019; Shan et al., 2020; Shen et al., 2017, 2020; Zhang et al., 2017; Ofori-Boadu et al., 2012; Shan and Hwang, 2018; Kamari and Kirkegaard, 2019; Andersson and Eidskog, 2020*). The following issues discussed in the papers – quality management system, document management system, management information, knowledge management, design management (integrated design, iterative decision-making process, workflows), technical and innovation-oriented factors, organizational settings, people management (competence, training, skills), strategic planning, customer focus, measurement, analysis, financial capability, risk management capability and so forth. – are compatible with *Oliveira’s (2005)* model. The management model has been tested in the PDGEP editions, and the guidelines of the present paper will provide feedback to the program.

From *De Paula (2016)*, *Doctorate* and *De Paula and Melhado (2018)*, JAE: A building design may be developed considering sustainability intrinsic to design decisions and solutions. As demonstrated by *Salgado et al. (2016)*, techniques of design and implementation harmonized through the project can naturally lead to solutions with high environmental performance. However, studies and statements are necessary to produce sustainability evidences to ensure performance during the building’s use, operation and maintenance phases; certify the building; or comply with technical regulations. Investment, technical knowledge, information, activities, agents and tools are automatically required in the design firms’ daily work for achieving those evidences. Therefore, changes are noticed most directly in the daily work practices adopted by firms for meeting the demands of sustainable buildings. Faced with that context, the firms have not entirely taken into account sustainability, especially in strategic management processes.

Regarding work practices and BIM in a relevant Brazilian architecture firm (*De Paula, 2016*), there was an adjustment in the timing when the data and information are used during the design stages and designers are hired. BIM requires definitions in the early design stages,

so designers of different disciplines are hired earlier in comparison to a traditional design process. This scenario stimulates the integrated design and supports the development of sustainable designs. Kamari and Kirkegaard (2019) presented BIM and integrated design potential, but Andersson and Eidenskog (2020) pointed management issues to achieve BIM benefits.

From De Paula et al. (2017), ECAM: An extensive exploratory survey of 43 questions was conducted in Brazil regarding environmental sustainability and management of building design firms (De Paula, 2016). Those questions became more meaningful and concise during the research conducted in the Construction Engineering and Management Program at the Illinois Institute of Technology (De Paula et al., 2017) and the case studies publication (De Paula and Melhado, 2018). Eleven questions were selected from the whole learning process (Table 3, Section B, diagnosing the firm's management and sustainability). The selection of questions focused on evidences of sustainability efforts in the managerial processes of design firms. The following evidence that sustainability has been taken into account were sought: documents, incentives, investments, requirement of knowledge about sustainable design, responsibilities, activities, agents, tools, firm's agreements and studies related to sustainability.

Table 2 presents study sources of the research path; references in bold type had the participation of this paper's authors. Line 1 shows papers related to PDGEP already mentioned above; the researchers were in an exploration stage. Line 2 demonstrates a justification stage of research relevance seeking knowledge about firms' system management in general and linking management and sustainability in the civil construction field. Although the concepts of firm, firm management system, management processes and business plan as a tool for future entrepreneurs or structuring products and services have been studied as theoretical foundation of the research path, they were not presented in this paper, delimiting the subject. The contribution of BIM to sustainability is taken into account in Table 2.

In Line 3, Table 2, there is a concern about expanding the sustainability concept. While the terms sustainable design, sustainable construction and sustainable building expand the sustainability requirements and dimensions, the word "green" means the focus is on the environmental dimension of sustainability – green design, green construction, green building, green technology, green innovation, green culture and so forth (Berardi, 2011). Other terms gain importance with the first group: durability, service life and performance (Agopyan and John, 2011). Also in Line 3, the idea of a sustainability plan in the guidelines came out by consulting AIA (2011) and BSRIA (2012) in order to deal with the challenge to develop requirement-based designs and the promotion of sustainability activities.

As can be seen in Line 4 of Table 2, this paper's authors' research production is concentrated in the environmental dimension, but the possibility of covering other dimensions was intentionally left open by employing the words sustainability and society, for example, so the guidelines structure can be useful in related proposals. Firms' management capabilities and sustainability or green buildings were explored, as mentioned above. Lastly, Line 5 is back to the firm system management completing the cycle with monitoring, control and feedback.

The firms' management difficulties affecting the development of building sustainable designs are shown in Table 2. The last column mentions the corresponding guidelines for overcoming those difficulties.

The management guidelines toward environmental sustainability for AE design firms are set in six items (A–F, Figure 4, Table 3). A, B and C are focused on understanding the firm's context and needs, and planning. A and B are particularly in a question format to achieve the firm's understanding by its efforts since each firm has its own characteristics and path of managerial maturity, while the other items are recommendations. D demonstrates

management as a support for sustainability. Lastly, E and F deal with putting the plan into practice, managing deviations; considering external and internal changes; realigning objectives, concepts, agents, resources and management processes; and promoting the continuous improvement cycle.

Returning to the question (Section 3) “*How could that research experience help AE design firms to fulfill their role in achieving sustainability and influencing clients and stakeholders?*,” the management difficulties and guidelines are discussed below, linking Tables 2 and 3.

Guideline A | Many AE design firms make sudden decisions without strategic planning. Understanding external and internal factors is important to conduct the firm considering its business and market demands. It is about the firm’s competitiveness and survival in the market. Sustainability, building performance and BIM are some demands AE firms could take into account.

Guideline B | Informal management processes have low efficiency in achieving design quality and hinder the promotion of better conditions for sustainable designs. Understanding the current situation of the firm’s management regarding sustainability is recommended to identify points to be worked on. Eleven questions of Guideline B investigate if sustainability is taken into account in the management processes. The questions were built on a research process – De Paula (2016), De Paula *et al.* (2017), De Paula and Melhado (2018) – being compatible with Oliveira’s (2005) model.

Guideline C | Sustainability can be intrinsic to design decisions and solutions, especially to essence of the conceptual design activity. However, sustainability certifications are composed by categories stimulating specialization in the building market. It means a set of consulting firms is participating in the building project, increasing the design process challenge in terms of integration, collaboration and communication. BIM has a potential for promoting the design process integration, highlighting the conceptual design relevance since BIM requires definitions in the early stages of design. Thus, BIM has an important role in achieving building sustainability goals through integrated design. Considering this scenario of sustainability, certification, performance parameters and BIM, a building Sustainability Plan (BSP) is recommended to identify points to be worked on according to the firm’s strategies.

Guideline D | Management processes are little explored to support sustainability. It is recommended to identify the BSP implications in the management processes to put actions into practice. Sustainability is linked to strategic planning, organizational structure, financial management, people management, business management and marketing, information system, planning and control of the design process and aggregate services, and performance evaluation (Figure 1 and Table 1 demonstrate the connection between management processes and sustainable design development).

Guidelines E and F | Informal management processes seem an issue in many AE design firms. Planning, monitoring, control, systematic evaluations and replanning are important to achieve efficiency and efficacy of actions.

5. Conclusion

This paper links management and sustainability. Lessons learned from a research experience and literature review led to the management guidelines on environmental sustainability for AE design firms. The guidelines were drawn up from a strategic sphere, understanding internal and external factors to the firm, diagnosis of the firm management and sustainability, a BSP, implications of the BSP for management processes, BSP monitoring and control and BSP evaluation.

Understanding sustainability as an inseparable issue of the conceptual design activity, designing based on sustainable and performance requirements and thinking buildings for society considering their long life are great challenges. The challenges are related to

mandatory requirements, such as minimum requirements of the performance standard (ABNT, 2013), master plan, legislation and public policies, and also related to the educational background of the professionals.

Sustainability certification brought changes regarding new activities, new agents and new tools in the building design process. Although some authors question the foreign certifications application, such as considering the country of origin's goals or being applied for marketing reasons in specific products or stimulating a reductionist view of sustainability (Silva, 2003; Silva *et al.*, 2003; Agopyan and John 2011; Berardi, 2011; Salgado *et al.*, 2016; Martek *et al.*, 2019; Salgado, 2019; Darko *et al.*, 2019), there are positive aspects such as raising environmental sustainability issues contributing to the awareness of requirements, outcomes, framework and industry common language (Berardi, 2011; Martek *et al.*, 2019) and the fact that sustainability studies gain space in the market despite the initial emphasis on energy simulation. Yet, the discussion should expand to terms such as sustainable building, durability, service life and performance and, further, evolving from technical issues to consider social interactions toward a real transition to sustainability (Martek *et al.*, 2019). While meeting certification categories requires specialization in the market, it means more segmentation and integration challenges. Among others benefits such as enabling performance simulations, BIM has a potential for improving this specialization and segmentation scenario through integrated design.

The findings reveal that the AE design firm's contribution to the sustainability scenario refers to being aware of its market context, society and client needs, products, market demands, innovation relationship, market positioning and management to define sustainability-related objectives; likewise, awareness about sustainability, performance and BIM preparing the firms and making strategic decisions. BIM is no longer an emerging topic, but a matter of competitiveness in the market.

The findings also point out that AE design firms have various managerial difficulties (Table 2) affecting the guidelines application. For example, how to relate the sustainability plan objectives to the firm strategic planning, if the firm does not have one? Overcoming those barriers would be a first step, since management provides more favorable conditions for the concepts already highlighted in this paper. Firm's needs can be understood by diagnosing and promoting solutions to improve the management system.

In conclusion, sustainability, performance and BIM demands have changed the design nature, gaining complexity due to the diversity of requirements, activities, agents and tools. AE design firms have observed them in their daily work. However, designers should be strategically prepared through formalized management processes, assuming those changes and understanding them as opportunities. Improvisations result in low efficiency processes with unproductive meetings, rework and stakeholders dissatisfaction.

This study was mostly conducted in Brazil, and one of them in the USA (De Paula *et al.*, 2017). The findings will provide feedback to PDGEP in the action research method. Other studies could be carried out in other countries, comparing findings or analyzing the guidelines application. Further research could explore AE design firm's capabilities for sustainability and BIM; BIM contribution to performance simulation; BIM and integrated design; strategic planning and sustainability in civil construction firms; agreements for sustainable designs; competencies for sustainable design; management contribution to life cycle analysis in civil construction firms. Also, other research methods could be adopted, such as focus group and design science research.

Professional class entities could give special attention to the topics sustainable building, sustainability, durability, service life, performance, simulation and BIM, playing effective and influential communication and dissemination channels. Civil construction firms could participate in exchange forums on sustainability, performance and BIM, such as legislation, software, academic studies, case studies and experiences from other countries. It is about the

possibility of engendering a debate on “sustainability culture” expanding the discussion focus beyond the question of certification.

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