KEYWORDS ▪ Project management ▪ Sustainable construction site management ▪ Product lifecycle management ▪ Sustainable civil construction

PERCEPTIONS OF SUSTAINABILITY IN CIVIL CONSTRUCTION PROJECTS: ANALYSIS OF BRAZILIAN CONSTRUCTION SITES

Sandra Moscon Coutinho, Ms.C.
Federal University of Espírito Santo, ES, Brazil

João Luiz Calmon, Ph.D.
Federal University of Espírito Santo, ES, Brazil
joao.gama@ufes.br

Darli Rodrigues Vieira, Ph.D.
UQTR Université du Quebec à Trois-Rivieres, Canada
darli.vieira@uqtr.ca

ABSTRACT

Although civil construction causes serious environmental impacts, it has significant social and economic importance. Its sustainable development is one of the challenges that need to be overcome in order to avoid irreversible environmental damage to future generations. Thus, sustainability should be inserted into the whole life cycle of a building, especially during the construction stage, by managing sustainable projects at construction sites. Using this setting, this descriptive and qualitative study aims at identifying the perceptions about sustainable practice during the construction stage. It presents methodology based on interviews and personal observations at construction sites in Brazil, using nine case studies in Vitória, Espírito Santo, Brazil. The results from the analyzed construction sites show that sustainable practices are incipient and still unsatisfactory. However, this study also shows that the scenario has changed because of requirements from an increasingly more demanding society which is aware of the environmental impacts caused by this activity.

INTRODUCTION

Environmental concern is a worldwide issue because its degradation reaches critical levels and dimensions. Themes concerning deforestation, greenhouse effect, recycling, desertification, global warming, among others, are present in the media and in discussions in several segments of society.

In the 20th century, rapid growth of cities brought several benefits to society, but also caused many environmental and socio-economic problems. Concerns about constant use of the planet's resources arose in the mid-1970s because of significant changes in the electrical sector and in energy planning activities, among them, the oil crisis that affected global economy. During this time, there was an increase in global concern about excessive exploitation of the environment by humans, urban development and environmental limits *(National Strategies for Sustainable Development, 2004)*.

This decade was, therefore, marked by the beginning of a series of events, conferences and treaties in Brazil and around the world, which contributed to spreading concepts involving sustainability. In 1987, in order to minimize environmental problems, the notion of sustainable development started to be recognized after the Brundtland Report, *(World Commission on the Environment and Development (WCED) (CMMAD, 1991)* was published. In this report, the term sustainable development had as its main directive the idea of interaction between economic development and environmental sustainability, in which growth of countries should be reached through ecologically feasible technology that is adaptable to their needs, so as to improve human quality of life.

Along with these events, between the 1970s and 1980s, the concepts of project management began their development and maturity process, resulting in the Project Management Body of Knowledge *(PMBOK)*, a set of project management practices published by the Project Management Institute *(PMI)*. Initially, the focus of interest was the big projects. Eventually, several areas of industries started to use the project management methodology to optimize their results, including the civil construction sector *(PMBOK, 2004)*.

This management guidebook provides references and maps in nine areas of knowledge: management of scope, time, cost, quality, human resources, communication, risks, acquisition, and integration *(PMBOK, 2004)*. In turn, due to the present moment of environmental preservation, environmental management, which is not yet part of the areas of knowledge, should be a transversal theme in all the nine areas mentioned.

In this setting, with multidisciplinarity involved, the role of the coordinators or project managers stands out. They will be the link between the process and several intervening factors, providing interaction between different information, people and situations *(Brown & Adams, 2000; Edum-Fotwe & McCaffer, 2000)*. According to Edum-Fotwe and McCaffer *(2000)*, project managers play roles outside the traditional management scope. The knowledge and skills needed to maintain their competence are acquired mostly from their own experience.

In the 1990s, Brazil and the civil construction sector began a process of significant changes in the political and economic scenario, marked mainly by the introduction of concepts of search and insertion of quality in this sector *(Evbuomwan & Anumba, 1998; Fabrício &Melhado, 2002)*. The quality management system through standard ISO 9001 seeks to make those decisions that are always taken towards the best performance and quality of the building. It strengthens the process of continuous improvement, and its actions and procedures help in the process of striving for sustainability.

Implementation of this system, as well as the environmental management systems *(ISO 14001)*; health and safety management *(OHSAS 18001)*; social responsibility management *(SA 8000)*, and other actions by construction companies, are expected by a society that is increasingly more aware and demanding in terms of environmental preservation.

Compared to others, the Civil Construction Industry *(CCI)* is the main source of environmental pollution. The production location is the construction site, which is exposed to the open air and generates a number of disadvantages and impacts. It is at the construction site that the final CCI product will be generated; a durable product that will cause impacts throughout its service life. These impacts concern loss of material and generation of waste, interference in the neighborhood and the environment *(water, soil, air)*, biotic *(flora and fauna)* and anthropic *(workers, neighborhood and society)* media where the construction takes place *(Araújo, 2009)*.

Although transitory, some of the effects generated during the construction stage, such as vibrations, noise and dust can cause health problems. Other effects can be considered permanent, such as high consumption of non-renewable natural resources, energy and water; emission of harmful gases, solid and liquid waste; among others *(Chen, Li, & Wong, 2000; Li, Zhu, & Zhang, 2010; Shen, Lu, Yao, & Wu, 2005)*. The process of adopting sustainable measures or strategies at construction sites is an essential factor for reducing environmental and social impacts deriving from this activity. This is key to spreading sustainability principles throughout the chain *(Araújo, 2009; Cardoso, Araújo , & Degani, 2006; Gehlen, 2008)*.

Faced with these premises, this descriptive and qualitative study aims at identifying the perceptions[1] concerning sustainable practices during the construction process of a building. Therefore, it presents a methodology based on interviews and personal observations at construction sites in Brazil, using nine case studies in Vitória, Espírito Santo, Brazil. To summarize, this article will discuss aspects concerning management of a product life cycle and sustainable project management at construction sites by explaining some concepts and presenting studies relevant to the theme. It justifies the need of locally-based investigation, followed by the methodology adopted in this study, and finally, the presentation of results and conclusions.

1 Perception or notion is how people see the world around them. It involves their values, ideas, and explanations about reality.

1. A literature review

1.1 Product life cycle management (building)

Product life cycle management comprises a set of processes to manage every stage of the cycle, seeking to integrate people, data, processes and systems. The sustainability approach in the constructed environment should take every step of the product life cycle into account *(**Figure 1**)*. In this study, the building is considered the product.

The life cycle of a building starts from the extraction and processing of raw materials, to the planning stage, which is essential for ensuring the most sustainable performance of the building. Then, the concept of the building is grounded through a preparation of needs analysis that will guide professionals through projects, detailing and technical specifications. Once this stage is finished, the construction site stage starts, which is when the undertaking actually begins to be carried out and the environmental impacts of the construction are realized.

These stages of a building's life cycle are the shortest ones, but carrying them out by adopting the best environmental performance and sustainability principles will be essential and will reap benefits during the next and longest stage: the use and occupation stage. In turn, the maintenance and repair stage is important for contributing to the extension of a building's service life. The demolition and generated waste management stage, which should be carried out with proper care and planning, ensuring reuse and recycling of materials *(Degani, 2010)*, completes the life cycle.

As previously mentioned, environmental impacts start to be noticed during the construction site stage. These are consequences of environmental aspects, that is, activities, services and products used in civil construction generate environmental aspects, which in turn cause environmental impacts. Identifying these aspects is necessary to understand the effects of the consequent environmental impacts and plan directives to minimize or eliminate the negative interferences caused to the environment *(Araújo, 2009; Degani, 2003)*.

Environmental impacts deriving from environmental aspects can take place at different levels: *(a)* in the construction environment *(labor informality, health conditions, workers' safety and welfare, air quality)*; *(b)* in its surroundings *(waste; air, visual and noise pollution; inappropriate motorways, interference in motorways because of irregular parking)*; *(c)* more wide-ranging, that is, in contact with the population in general and the environment *(air, water, and soil contamination; depletion of resources) (Gehlen, 2008; Nian & Soares, 2004)*.

In order to control or reduce these environmental impacts, technologies and management actions should be defined so as to establish human resources and materials: appropriate equipment, trained and qualified professionals, and effective tools to manage the product life cycle and sustainable product management at construction sites *(Araújo, 2009; Degani, 2003; Degani, 2010)*.

1.2 Sustainable product management at construction sites and related studies

Managing sustainable projects at construction sites corresponds to management focused on reducing environmental impacts, and it should be present at the beginning of the building's life cycle. In an international context, Gangolells et al. *(2009)* propose a quantitative methodology to foresee the environmental impacts related to the construction process of residential buildings. This methodology addresses the question of environmental aspects and impacts, referring to the activity carried out at construction sites, and it uses an assessment process based on the duration of the impact and chances occurring.

Some categories of environmental aspects, derived from the study by Gangolells et al. *(2009)*, are studied *(consumption of resources, water, generation of residue, pollution emission, alterations in soil, in biodiversity, among others)* and assessed before the construction stage. This way, a set of measures can be implemented to mitigate the negative impacts during the activities at the construction site. The authors mentioned above concluded that the methodology proposed can help companies implement environmental management or can help them improve their environmental performance.

More recently, Gangolells et al. *(2011)* complemented the previous study by adding another criterion to the assessment table existing in the previous study, in which the demands of stakeholders are brought to the assessment process, completing the methodology presented earlier.

The civil construction sector in Brazil is characterized by a low level of industrialization, high waste rate of materials and restricted qualification of labor. Sustainable project management at construction sites is still a recent theme. Much is said about sustainable management concerning the stage of use and occupation of buildings, that is, architectural solutions involving lighting, energy efficiency, water use efficiency, thermal comfort, user's health, ventilation, and finished materials, among others.

However, one of the greatest environmental impacts in civil construction can be found at the construction site of a building. Many researchers have sought solutions to the production of buildings and their best performance, involving the following themes: alternatives for reducing material waste, water and energy, reusing and recycling and reduction of impacts deriving from construction sites.

Some available publications stand out. Degani *(2003)* shows a study on environmental aspects and impacts caused by civil construction at construction sites through the matrix: "environmental aspects versus environmental impacts". Environmental aspects refer to causes resulting from activities carried out *(such as consumption and waste of resources, water and energy)*, and environmental impacts, which refer to effect or consequence of these aspects *(for example, resource depletion)*. Due to the need of minimizing the impacts, the author proposes a methodology to implement the system of environmental management in construction companies.

Cardoso et al., in turn, *(2006)* present an advance in the constitution of the matrices "environmental aspects versus impacts" of Degani's study *(2003)*, confirming the diversity of impacts caused by construction sites, which go beyond material losses and waste production. Their conclusions present an organization of the concepts and information obtained from the use of matrices that relate activities, products or services carried out at construction sites to environmental aspects *(cause)* and environmental impacts *(effect)*.

Resende's study *(2007)* shows that, among the impacts caused to the environment by civil construction activities, is the emission of particulate matter in the atmosphere, which is responsible for a series of respiratory and cardiac problems, damage to fauna and flora, neighborhood nuisance, damage to soil, air and water. The study identifies the main sources of particulate matter, the main tools to control and prevent it, and the main applicable monitoring methods for construction sites. The author concludes that control is perfectly applicable to Brazilian construction companies.

Gehlen's study *(2008)*, in turn, contributes to forming a data base about the practices adopted by construction companies during the works in the Federal District *(DF)*, Brazil, in order to verify the sector's preparation for sustainability.

Araújo *(2009)* highlights the importance of the study on reduction of negative impacts caused by the construction stage. This study aims at proposing practices to be adopted by construction companies at their construction sites in order to achieve a more sustainable building production process in urban areas. These practices proposed involve technological and managerial directives, along with a guide that proposes a strategy to implement more sustainable construction sites.

Lima's study *(2010)* investigates sustainability aspects in construction sites in the cities of São Paulo and Recife *(Brazil)* and proposes directives to implement sites with less environmental impacts based on the technical data sheet AQUA *(FCAV, 2010)*.

Vasconcelos *(2013)*, however, proposes a model of guidelines for assessing sustainable construction sites through the interaction of lean philosophies, green building and wellbeing with sustainability in the civil construction market. He applies the method used in construction sites in Fortaleza, Ceará *(Brasil)*.

Finally, Blumenschein et al. *(2013)* believe that sustainability in Brazil is only beginning. Regarding construction sites, there are great challenges to the process of introducing strategies that minimize and control environmental impacts. The authors believe that learning systems need to be strengthened. Once the strategy is learned, new paradigms are absorbed and solutions with different points of view can be spread and implemented.

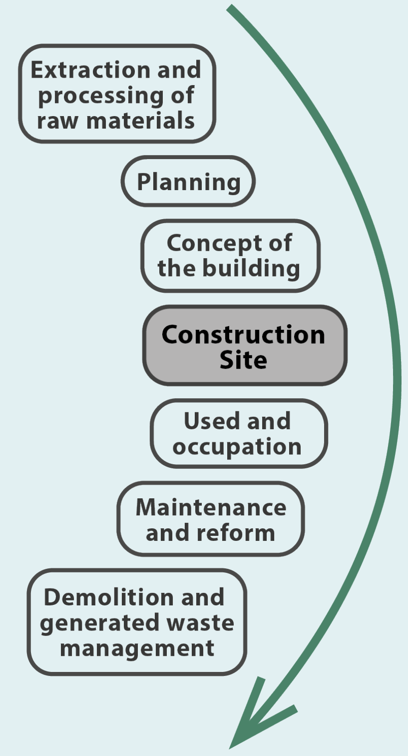

FIGURE 1. *Scheme of the building's life cycle stages*

It can be noted that there is a variety of themes related to sustainable management at Brazilian construction sites under study. This is due to a demand for new ideas, solutions and better practices. In Brazil, the recent changes that occurred in Sistema de Avaliação da Conformidade de Empresas de Serviços e Obras da Construção Civil[2] of Programa Brasileiro de Qualidade e Produtividade do Habitat *(SIAC PBQP-H)* in late 2012, will certainly contribute to the increment of sustainable management at Brazilian construction sites. Among other changes, construction companies in the subsector of buildings should provide indicators that include the following items related to sustainability at construction sites: waste, water consumption and energy consumption *(Referencial Normativo, 2012)*. Consequently, the companies should comply with the new requirements in order to retain their accreditation.

Faced with great challenges and opportunities, it is necessary to rethink this activity and try to construct in a way that is less aggressive to the environment, which motivated this present investigation.

2. Reaserch method

This study is classified as descriptive *(it aims at describing the characteristics of a particular population through*

2 SIAC is one of the PBQP-H projects, which aims at assessing compliance of the quality management system of service and construction companies, taking into account the specific features of these companies' activities in the civil construction sector based on ISO 9001 standards.

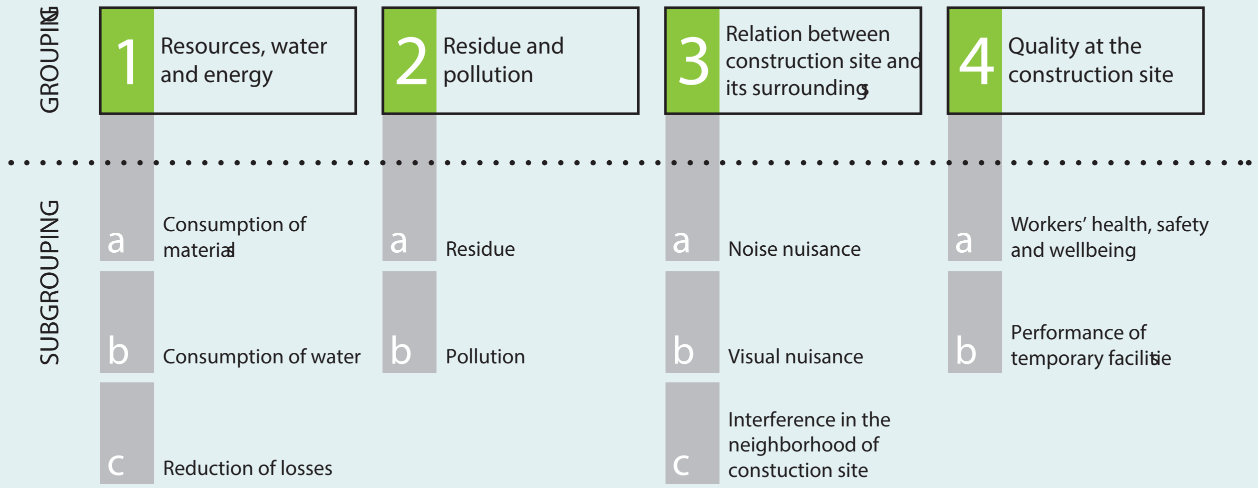

FIGURE 2. *Scheme of grouping and subgrouping of the questionnaire*

Options of answers in the questionnaire	Given Value
YES, GREAT AND GOOD	Positive (identify actions carried out that contribute to sustainability at the site)
NO, NEVER, SOMETIMES, FAIR OR POOR	Negative (identify necessary improvements)

TABLE 3. *Relationship between questionnaire answers and given values*

Total of questions in the group	---	100%
Number of positive answers	---	X

TABLE 2. *Calculation of percentage of positive answers per grouping*

the use of standard techniques for data collection: questionnaires, observation, analyses and others), and adopts a qualitative approach *(once descriptive data is obtained by researcher's direct contact with the study object situation)*. The research method used was data collection based on and complemented by a literature review.

In order to carry out the study, an assessment instrument was administered. It comprised a questionnaire *(54 questions)*; list of direct observations; and list of photographic records *(33 items regarding the questionnaire)*. Its production was based on the analysis of environmental development assessment methodologies LEED *(GBC Brazil, 2013)* and AQUA *(FCAV, 2010)* on aspects concerning construction sites in the national literature *(Cardoso, Araújo, & Degani, 2006; Degani, 2003; Gehlen, 2008; Niang & Soares, 2004; Priori Junior, 2007; Resende, 2007)*, and mainly on strategies to implement more sustainable construction sites suggested by Araujo *(2009)*.

The questionnaire was divided into theme groups *(grouping and subgrouping)* to facilitate understanding and compilation of results *(**Figure 2**)*.

The list of observations and photographic records allow the assessment instrument to follow the theme groups of the questionnaire and have a pre-established script, which aims at providing the researcher with a means to immediately verify the information given by the respondents.

The average length of interviews, foreseen and previously informed, was sixty minutes. Since respondents were free to express their opinions and give examples of the items asked, in some interviews, this length was exceeded. Visits to construction sites with photographic records had also been agreed before and they took place after the interviews. Two visits to each site were enough to fill out the whole list.

The questionnaire has mixed questions: multiple choice and open-ended. The options of answers to the multiple choice questions were divided into positive *(identify actions carried out that contribute to sustainability)* and negative *(identify necessary improvements)* and they are presented in **Table 1**. The partial structure by grouping of the questionnaire can be seen in Tables 6, 7, 8 and 9 in this article.

The results of each grouping, presented in **Figures 3, 4, 5** and **6** were obtained through a simple rule of three, in which the total questions in the grouping correspond to 100% and the number of positive responses obtained corresponds to X *(**Table 2**)*.

Finally, **Figure 8** presents the global results per site *(RGC)* by calculating the means of positive results obtained in the four groupings. This calculation was carried out by applying equation 1 *(eq. 1)*, presented in **Table 3**.

We understand that the theme used in the groupings is equally important when we discuss sustainability at construction sites. Thus, no heavier weight was attributed to one or another grouping. Therefore, the final result is presented by calculating the means of positive results obtained from each grouping.

3. Analysis of results

This article will present the main results obtained, the full research *(methodology, questionnaires used during the interviews and personal observations at construction sites, and their complete results)* can be seen in Coutinho *(2013)*.

The undertakings visited have the following characteristics in common: a) they are located in urban areas; b) they are construction sites of buildings comprised of multiple floors and a conventional construction system; c) they belong to companies headquartered in the State of Espírito Santo, Brazil; they are companies associated with the Civil Construction Union of Espírito Santo *(SINDUSCON-ES)* and have significant participation in the local real estate market.

3.1 Characterization of sample

In this study, identification of the construction sites visited, the owner-companies and respondents are kept confidential. Their main characteristics are described in **Table 4**.

The sites visited were at different stages of construction, seven of them were in their final stages *(**Table 5**)*.

The respondents at the time were in charge of sites, eight of them were engineers *(ENG)* and only one site, CS-8, had an architect *(ARC)* in charge. Seven out of the nine respondents reported having postgraduate and specialization degrees compatible with the field, and over 18 years working in this market. These results indicate a high level of knowledge about construction techniques among the respondents in this study. The results obtained in the questionnaire per grouping are presented next.

3.2 Grouping 1 – resources, water and energy

In this group, we investigate the perception of respondents about consumption of materials, water and energy and reduction of losses at construction sites, using 16 questions. Among other aspects, the following are asked: a) reasonable use of water and energy through reusing, saving equipment and others; b) the process of choosing materials and components to be used in the construction, preference given to recyclable materials or materials containing recyclable or reusable components, available near the site, and certification of product traceability; c) organization and planning of site aiming at its different stages, such as storage of materials, horizontal and vertical transportation to reduce losses and increase productivity. Some questions in the questionnaire referring to this group are shown in **Table 6**.

After considering the answers obtained in the questionnaire *(positive or negative)* as per **Table 1**, the percentage of positive answers was achieved for each site visited. These percentages are shown in **Figure 3** and they indicate the actions taken at the construction sites that contribute to its sustainability.

It is seen that CS-1 had better results *(78%)*, followed by sites CS-2 and 4 *(64%)*. In turn, CS-08 and 9 had the lowest scores *(28%)*, with most necessary improvements identified. Among the positive items most frequently identified in the answers of this group, we can list: practice of reusing components and construction systems of temporary facilities in other sites and calculation of mortar and other material use per day. Among the least mentioned items, which indicate necessary improvements are: use of alternative sources of water and energy and preventive inspections besides the corrective ones in the hydraulic equipment.

3.3 Grouping 2 - Residue and pollution

In this group, we investigate the perception of respondents about residue and pollution generated at the sites using 19 questions. Among others, the following items are questioned: a) performance of waste management project; b) proper segregation of waste in the different classes established by the National Council for the Environment *(CONAMA)* resolution no. 307 *(Brasil, 2002; 2011)*, as well as its reuse at the site, its forwarding to recycling or proper disposal; c) concern about control and limitation of nuisance regarding air, soil and water pollution. Some questions in the questionnaire referring to this group are shown in Table78.

Percentage of positive answers obtained for this grouping, shown in **Figure 4**, show that actions carried out at the sites visited contribute to sustainability. To calculate this result, the relationship between the answers and values *(positive or negative)* as per **Table 1**, shown earlier, was taken in to account.

It can be noted that the score between site CS-1 and 4 was the highest and equal to 93%, showing a large difference

$$\text{Global result per construction site (RGC) (\%)} = \frac{\text{\% obtained from Grouping 1} + \text{\% obtained from Grouping 2} + \text{\% obtained from Grouping 3} + \text{\% obtained from Grouping 4}}{4}$$

TABLE 3. *Equation 1, used for calculating RGC*

in score compared to other sites. Site CO-2 shows 56% and sites CO-3 and 6 had the lowest scores *(37%)*, which shows that improvements are needed in several items.

Overall, the items most frequently mentioned, that contributed to sustainability were: carrying out a waste management project, hiring accredited companies to transport and dispose residue. In turn, the least frequently mentioned, showing necessary improvements were: reusing construction and demolition waste in the construction itself; need of changing construction processes to reduce the waste generated; need of wheel-washers at the exit of vehicles and washing areas with retention devices to avoid soil and water table contamination, among others.

3.4 Grouping 3 – Relationship between construction site and its surroundings

In this group, we investigate the perception of respondents about noise and visual nuisance and interference in the neighborhood of construction sites, using 8 questions. Among others, the following items were used: a) performance of activities that emit noise or vibration at the site during hours permitted and in compliance with noise limits, as well as planning strategies to minimize this nuisance; b) maintenance of motorways and sidewalks and planks, as well as their use in recyclable material; c) frequent cleaning around construction; and d) reduction of nuisance caused by driving and parking of vehicles around the site by planning flow schedules, proper signaling and parking lot for employees and visitors. Some questions in the questionnaire referring to this group are shown in **Table 8**.

Figure 5 shows the percentage of positive answers obtained in this grouping, with the answers of the questionnaire applied, and they indicate actions carried out at the construction site that contributes to sustainability. Thus, the values *(positive and negative)* were taken into account, as per **Table 1** in Methodology.

It can be noted that the score in CS-1 was the highest, 87%, followed by four sites with 75%: CS-3, 4, 5 and 9. The sites with the lowest scores were CS-07 and 8, which shows that several aspects referring to this group need improvement. Among the items most frequently mentioned were the items that contributed to sustainability. We can list compliance with hours in which noisy activities and nuisance to neighbors are allowed; maintenance of planks and making use of recyclable materials. The least frequently mentioned were: existence of parking for visitors, employees and suppliers, proper maintenance of motorways and sidewalks around the site.

3.5 Grouping 4 – Quality at the construction site

In this group, we investigate the perception of respondents about workers' health, safety and wellbeing and performance of temporary facilities using 11 questions. Among other aspects, the following are looked at: a) conditions of personal and collective protective equipment, as well as adequate signing regarding safety; b) conditions of temporary facilities regarding solutions adopted, thermal and acoustic comfort, lighting, ventilation and air quality. Some questions in the questionnaire referring to this group are shown in **Table 9**.

After considering the answers obtained in the questionnaire *(positive or negative)* as per **Table 1**, the percentage of positive answers was achieved for each site visited. These percentages regarding Grouping 4 are shown in **Figure 6** and they indicate the actions taken at the construction sites that contribute to its sustainability.

Overall, the scores of this group were better, compared to the previous groupings. Sites CS-1 and 3 achieved 100% of positive answers, in turn; sites CO-7 and 9 achieved 54%. Among the most frequently mentioned items, those regarding health and safety of workers had the highest scores, which shows strict compliance with standards. The least frequently reported items regarded performance of temporary facilities in terms of thermal comfort and ventilation.

3.6 Final Results

Figure 7 shows the results of percentages of positive answers for each construction site, and each grouping investigated.

The lowest percentages of positive responses are concentrated in Grouping 1 *(resources, water and energy)* and 2 *(waste and pollution)*, which shows that there is much to be done to improve consumption reduction and waste generation.

Grouping 3 *(noise, visual nuisance and interference in the surroundings)* showed results slightly better than the previous ones. Finally, Grouping 4 *(Workers' health and safety and performance of TFs)* showed the best results among the four groupings in the study.

To these results, equation 1 *(eq. 1)* was applied, as described in item 2 of this article. The RGC obtained is shown in **Figure 8**.

Thus, CS-1 showed the highest score *(90%)*, followed by CS-4 *(76%)*. Sites CS-2, 3 and 5 took the following positions. CS-3, despite having presented the lowest results in groupings 1 and 2, attained a good global result *(62%)*. CS-6 had low results in the three first groupings.

Construction Site (CS)/ use of building	Company (CO.) to which it belongs	Size of company / time in the market (years)	Standards:	Building undergoing process of sustainability accreditation	Respondents (EHG or ARC) / years in the market
CS-1/Commercial	CO. A	Large Size /27	SGI *1	No	ENG *2 1/ 20
CS.-2/mixed	CO. B	Medium Size/33	ISO 9001	No	ENG 2/ 25
CS.-3/mixed	CO.C	Medium Size/24	ISO 9001	No	ENG 3/ 10
CS-4/Commercial	CO. B	Medium Size/33	ISO 9001	Yes (construction site under accreditation process)	ENG 4/ 32
CS-5/residential	CO. D	Small Size/25	In implantation ISO 9001	No	ENG 5/ 20
CS-6/mixed	CO. E	Small Size/31	ISO 9001	No	ENG 6/ 13
CS-7/residential	CO. F	Small Size/29	ISO 9001	No	ARQ*3 1/ 34
CS-8/residential	CO. G	Medium Size/32	ISO 9001	No	ENG 7/ 6
CS.-9/mixed	CO. H	Micro business /42	ISO 9001	No	ENG 8/ 18

*1 SGI: Integrated Management System, that is, company that has standards ISO 9001, ISO 14001, OHSAS 18001 and SA 8000 implanted.
*2 ENG: Engineer
*3 ARC: Architect

TABLE 4. *Main characteristics of construction sites, companies and respondents*

Initial Stage	Intermediate Stage	Final Stage
Corresponds to earth leveling and foundations	Corresponds to large amount of production: structure, covering, brickwork and installations	Corresponds to tiling and finishing
CS - 2	CS - 3	CS-1; 4; 5; 6; 7; 8 and 9

TABLE 5. *Stage of Construction Sites*

Regarding choice of materials for the job, is there any concern about buying products locally?
(...) YES (...) NO (...) NEVER (...) SOMETIMES

Regarding choice of materials for the job, is there any concern about buying products with low levels of toxicity?
(...) YES (...) NO (...) NEVER (...) SOMETIMES
If so, give examples:

Were the components and constructive systems of temporary installations reused in other construction sites?
(...) YES (...) NO (...) NEVER (...) SOMETIMES
If so, list them:

Regarding water consumption, does the site use water-saving components and technology?
(...) YES (...) NO Which ones:

Does it use alternative sources to capture rainwater for non-drinking purposes (cleaning, garden watering, etc.)?
(...) YES (...) NO Which ones:

Are amounts of mortar and other materials calculated for daily use in order to avoid losses?
(...) YES (...) NO Comments:

TABLE 6. *Configuration of part of the questionnaire concerning Grouping 1*

However, its score was high for the fourth grouping, with a final result of 55%. Sites CS-7, 8 and 9 had results of 50% or less, which shows that many items investigated need to be revised and improved at these construction sites.

The results achieved by CS-1 and CS-4 are certainly due to the fact that the former belongs to a company accredited with ISO 14001, of environmental management, among other standards; the second site was undergoing a process to obtain sustainability certification LEED at the time of the study. These factors lead to actions regarding sustainability at construction sites and contribute to their good performance. The search for making buildings with sustainability certification is not yet a reality among the construction companies analyzed. However, this is a trend and clients are increasingly more demanding.

The sites visited belong to construction companies classified as medium and large sized, having operated in the market for a long time, several ongoing undertakings and certifications ISO 9001. These facts, however, do not change

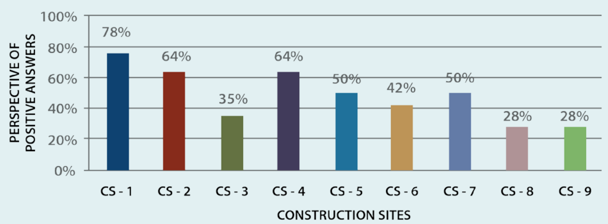

FIGURE 3. *Percentage of positive answers: Grouping 1*

Are the companies hired for disposing waste duly registered (accredited for transportation and destination)? (...) YES (...) NO Comments:
Regarding disposed products that can be recycled (paper, plastic, cardboard), are they taken to recycling? (...) YES (...) NO If so, list them:
Was the waste generated at this site recused at any time in the constructin itself? (...) YES (...) NO Comments:
Was reverse logistics carried out (return product waste to manufacturers) with any material at this site? (...) YES (...) NO Comments:
Are employees advised not to spill oil, grease or other dangerous material in the sewers or water table? (...) YES (...) NO ( ) SOMETIMES Comments:
Is wet sweeping adopted, that is, sweeping using water to avoid dust? (...) YES (...) NO (...) SOMETIMES
Is waste disposed wet through disposing tube in the facade? (...) YES (...) NO Comments:
Are ponds planned decating water containing particulate matter (water for washing trucks or their wheels, equipment with mortar, concrete)? (...) YES (...) NO Comments:

TABLE 7. *Configuration of part of the questionnaire concerning Grouping 2*

the conservative and traditionalist characteristics and resistance to changes existing in the sector.

4. Final Considerations

This article presents the results of perceptions of sustainability at some construction sites in Brazil through the use of an assessment instrument that was created and administered. It identified good practices as well as necessary improvements per group analyzed and construction site visited.

The results found are no different from those found in previous studies carried out in other Brazilian cities. This can be a sign that sustainability in the construction stage is still in its initial stage, takes place in a precarious and non-systemized way, and still has a long way to evolve. The changes occurred recently with SIAC PBQP-H and will certainly contribute to sustainability at construction sites, if monitoring and strict compliance with standards in force take place.

Some general suggestions can contribute to success in achieving a construction site with low impact, among them: a) participation of employees in training programs or courses concerning sustainability at construction sites; b) involvement and commitment of managers and employees; c) establishment of an effective routine through monitoring, measuring and inside auditing; d) use of computer programs to measure and record indicators of material, water and energy consumption, losses, waste generated, disposed and reused, among others, to control and minimize their effects; e) guarantee of resource availability: technological, human, financial; and f) meetings for critically analyzing and planning continuous improvement and assessment of the benefits achieved.

There are great challenges to this process, but also great opportunities, because adopting measures for sustainable project management at construction sites can still make a difference in Brazil, and the pioneering companies can stand out. Thus, many will benefit: the construction companies themselves, site workers, building neighbors, society and the environment.

Are the jobs that cause vibrations or noise, such performance of foundations, pouring of concrete, drilling, sawing, among others, performed at hours that cause less nuisance to neighbors? (...) YES (...) NO (...) SOMETIMES Comments:
Are the planks made of reclycled or recyclable material? (...) YES (...) NO Comments:
Is there any concern about visual communication of the construction and maintenance of planks? (...) YES (...) NO (...) SOMETIMES Comments:
Is there any concern about conservation of motorways and sidewalks to ensure accessibility? (...) YES (...) NO (...) SOMETIMES Comments:

TABLE 8. *Configuration of part of the questionnaire concerning Grouping 3*

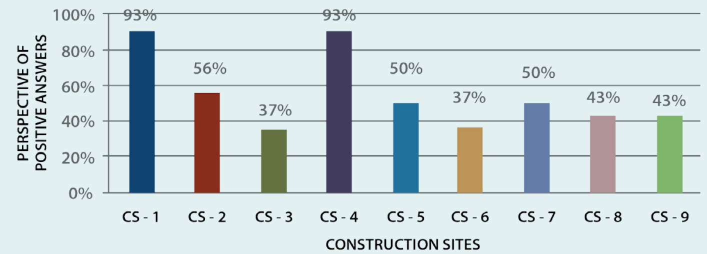

FIGURE 4. *Percentage of positive answers: Grouping 2*

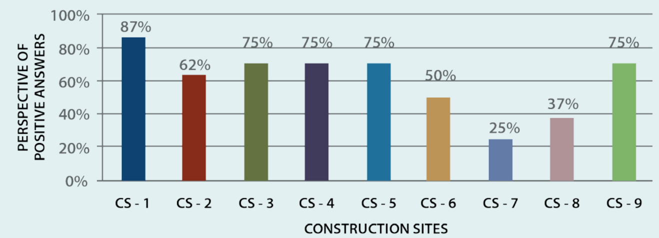

FIGURE 5. *Percentage of positive answers: Grouping 3*

Table 10 – Configuration of part of questionnaire concerning Grouping 4

Are signs regarding safety located inside the construction site? (...) YES (...) NO (...) SOMETIMES Comments:
How do you see health and hygiene condition of restrooms and locker rooms of temporary facilities? (...) Great (...) Good (...) Fair (...) Poor Comments:
How do you see health and hygiene condition of dining rooms of temporary facilities? (...) Great (...) Good (...) Fair (...) Poor Comments:
How do you see the technical solutions adopted for temporary facilities at this construction site? (...) Great (...) Good (...) Fair (...) Poor Comments:
How do you see thermal and acoustic comfort in temporary facilities at this construction site? (...) Great (...) Good (...) Fair (...) Poor Comments:
How do you see lighting, ventilation and air quality in the temporary facilities at this construction site? (...) Great (...) Good (...) Fair (...) Poor Comments:

TABLE 9. *Configuration of part of the questionnaire concerning Grouping 4*

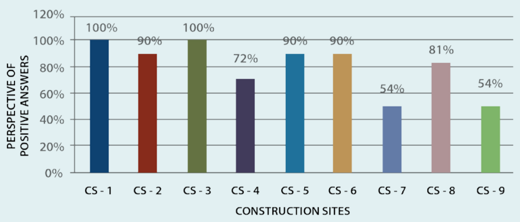

FIGURE 6. *Percentage of positive answers: Grouping 4*

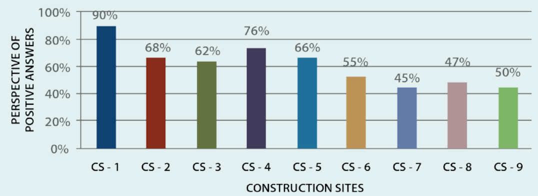

FIGURE 8. *Global result per construction site (RGC)*

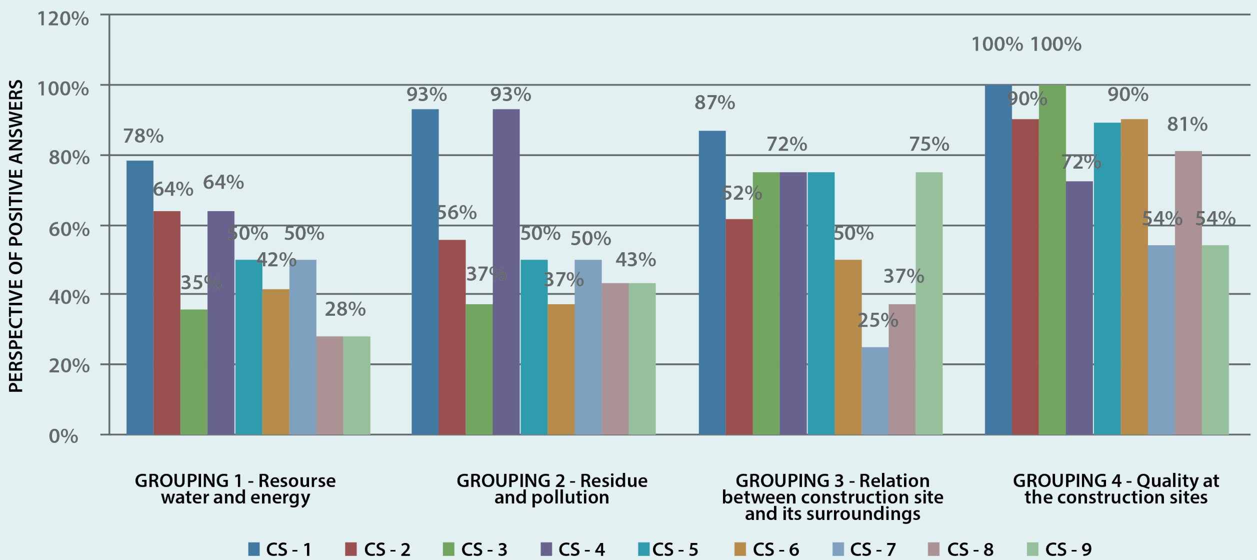

FIGURE 7. *Final result of questionnaire per grouping*

authors

Sandra Moscon Coutinho is an architect graduated from Federal University of Espírito Santo, Brazil, where she also received her master degree in civil engineering. She also has MBA in business management of construction from UCL, Brazil. She is a researcher and consultant in sustainable construction site management and sustainable civil construction. She has professional and academic experience in architecture and urbanism, with an emphasis on design and sustainable architecture, mainly teaching subjects related to technology, sustainability and architectural design.

Darli Rodrigues Vieira, Ph.D. is a professor at the Université du Québec à Trois-Rivières – Canada, and holds the research chair in Management of aeronautical projects. Previously, he was a professor at the Federal University of Parana (UFPR) and the Instituto Tecnologico de Aeronautica (ITA). He is the author of several works, among which stands out the following recent books: Analysis and design of logistic networks (with Alain Martel), Distribution Centers Project (with Michel Roux), Audit Logistics (with Michel Roux) and Product Design Management (with Abdelaziz Bouras and Denis Debaecker). His professional experience includes over 20 years of activities in the aeronautical, automotive, steel, cosmetics, telecommunications, and ports sectors, etc.

João Luiz Calmon is a Professor at UFES - Federal University of Espírito Santo), Vitória, Brazil. He received his BSE in civil engineering from UFES; his MSE in Production Engineering from Catholic Pontific University, Rio de Janeiro, Brazil; his Ph.D. in civil engineering from Catalonia Polytechnic University, Barcelona, Spain; and his Post-Doctorate degree from Eduardo Torroja Institute for construction Science, Madrid, Spain. His research interests include project management; cleaner production; Finite element method applied to construction processes and structures – Thermal stress (dams, large foundations); high-temperatures in structures; concrete technology, durability of structures, use of waste and industrial by-products as building materials, sustainable construction.

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