Identification of the Primary Needs for Sustainability and Improvements in Working Conditions on Construction Sites

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Abstract

The construction phase of a building´s life cycle accounts for a significant portion of the environmental impacts caused by the industry, such as contamination, waste, dust emissions and noise. Therefore best practices and technological solutions aimed at rationalising resource use, reducing emissions and increasing the environmental performance and energy efficiency of site equipment and tools, hydraulic and electrical installations, and improving the health, safety and well being of the workers and surrounding community are required. In Brazil, there is a lack of knowledge with regards the primary needs for improving sustainability and working conditions on construction sites. The aim of this work was to identify the priority research areas for improving sustainability and working conditions on construction sites in Brazil. The study consisted of a literature review of the environmental assessment methods to formulate the survey with questions for each possible priority research area allocated within the established themes. The survey was applied to building companies in four cities in Brazil (Salvador - Bahia, São Paulo, São Carlos - São Paulo and Porto Alegre - Rio Grande do Sul). The priority research areas for sustainability and improvements in working conditions on construction sites with special emphasis on low income housing projects were identified. These results are expected to produce guideline proposals for new science, technological and social policies aimed at improving environmental sustainability and working conditions on construction sites with special emphasis on low income housing projects.

Keywords: Sustainable Construction Sites, Health and Safety, Low income housing.

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1. Introduction

On a global scale, the construction industry is responsible for approximately 50% of the CO2 emitted into the atmosphere, 20 - 50% of all natural resources consumed and 50% of all solid waste produced for which the construction phase of a building´s life cycle is largely accountable, causing a series of environmental impacts as a consequence (Probert, 2010, Khasreen, 2009, Cardoso et al. 2006, Pulaski, 2004). The construction process in itself causes several and different environmental impacts (Kilbert, 2005; Polaski 2007, USEPA 2006, Chelma 1997). Large quantities of materials, water and electricity among other resources of various types and origins are consumed on construction sites during the different production activities and by temporary facilities. These activities also generate waste materials and particle emissions that cause a concern regarding soil contamination and air pollution. Water pollution and soil erosion is also a problem. Furthermore, the impacts resulting directly or indirectly from the construction site production activities can create problems related to the health, safety and welfare of site workers and neighbourhood.

In Brazil the impacts resulting from construction and demolition waste and its clandestine disposal have been regulated through the Resolution, number 307, created in 2002 by The National Council for the Environment (CONAMA) which regiments the management and disposal of construction and demolition waste. As a result researchers have given much attention to developing solutions in reducing construction waste generation, management, recycling and its reuse within the productive chain (Evangelista et al., 2010, John, 2000 and Pinto, 1999). However, studies performed by Cardoso et al. (2006) on the environmental impacts resulting from the construction site activities and their respective environmental aspects conclude that environmental impacts go much further than those related to waste generation and include the interferences with the neighbourhood and on the physical, biological and anthropic environments caused by the different construction site activities. Besides this, such interferences with the local environments have received little attention to date from building companies, professionals and academics despite the significant impacts caused by them (Cardoso et al., 2006).

To better understand the relationship between site interferences and impacts, Araújo (2008) created a matrix relating environmental impacts to environmental aspects which were then related according to services performed on the construction site. Many of these impacts can potentially be controlled by the project team during the design and construction phase of a building (Kilbert, 2005; Cardoso, 2006). Further studies include predictions of impact magnitude, indicators for monitoring impacts and guidelines for implementing mitigation measures (Silva, 2007; Araújo, 2008). Therefore, considering the size and importance of the impacts caused by construction site activities, it is necessary that the construction industry addresses issues aimed at improving the sustainability of the construction phase of a building's life cycle. This however, requires a close collaboration among building owners, developers, architects, engineers, contractors and construction firms, facility managers, and real estate professionals. In Brazil, there is a lack of data and knowledge with regards the primary needs for sustainability and improvements in working conditions on construction sites. Several aspects may require research and the development of best practices aimed at rationalising resource use, reducing emissions and increasing the environmental performance and energy efficiency of site equipment, tools and temporary facilities. Research aimed at improving the environmental quality, such as the health, safety and wellbeing of the site operatives and the surrounding community may also be required.

The aim of this work is to identify the priority research needs in sustainable technological solutions and improvements in working conditions on construction sites. The method of this work is based on a literature review of the different environmental assessment methods of buildings such as LEED (USGBC, 2009), BREEAM (BRE, 2009), and the Brazilian methodologies such as the AQUA Process (High Environmental Quality) and the Selo Casa Azul CAIXA (Blue House Seal from the CAIXA Bank), with particular emphasis on the construction phase of the building's life cycle. From this, a survey was formulated and applied to building companies in four cities in Brazil and their surrounding regions: Salvador - Bahia, São Paulo, São Carlos - São Paulo and Porto Alegre - Rio Grande do Sul.

2. Contribution of the Environmental Assessment Methods towards Sustainability on Construction Sites

Although all assessment methods show differences within their methods of criteria evaluation and their categories and themes in which criteria are distributed, it can be seen that all criteria fall under similar themes forming a flow system related to inputs and outputs (consumptions and emissions) within the physical, biotic and anthropic context of the construction enterprise. This flow system of inputs and outputs was also discussed by Degani, (2003) where the aspects relating to the sustainability of the built environment were subdivided into the following categories: (a) inputs; (b) outputs; (c) relationship with the external environment, (d) internal environment quality; (e) operation and use; (f) maintenance and renovations. Looking more specifically at the contributions of each method towards sustainability on construction sites, it was found that some methods gave more emphasis to this stage of the building project than others.

According to the U.S. Green Building Council guidelines (2009), the LEED method refers to the impacts caused by the construction site activities within its Sustainable Sites category. One prerequisite refers to Construction Activity Pollution Prevention which requires implementation of plans aimed at reducing the pollution arising from construction activities through controlling soil erosion, waterway sedimentation and airborne dust generation. It also emphasises the need to reuse building materials, adopt a materials selection policy using regional and rapidly renewable materials and incorporating recycled content into the new construction. It also requires implementation of a Construction Waste Management plan within its Materials and Resources category. The Indoor Environment Quality category allocates a credit on implementing a Construction Indoor Air Quality Management Plan during the construction phase. Within this credit, considerations must also be made to protecting onsite stored materials and absorptive materials from moisture and contamination. The use of air handlers as temporary heating and cooling systems to protect the well-being of construction workers must be addressed. Four additional credits are awarded for the use of toxin free and low volatile organic compound emitting materials and implementing control measures when materials containing VOC's are used in order to protect the health of installers and building occupants (U.S. Green Building Council, 2009).

The BREEAM method awards credits in an issue titled “Constructors’ Environmental and Social Code of Conduct within the BREEAM Management Category which emphasises the need to recognise and encourage construction sites which are managed in an environmentally and socially considerate and accountable manner (BREEAM Europe Commercial Manual, 2009). According to the manual a checklist divided into four sections is provided: Safe and adequate access, Good Neighbour, Environmentally Aware, and Safe and Considerate Working Environment. The safe and adequate access section provides best practices guidelines regarding car-parking, site entrances and exits, pathways, street lighting, scaffolding, site fencing and road signs. The good neighbour section provides best practices aimed at reducing noise pollution arising from site activities, and both visual and light pollution inflicted upon the local neighbourhood. Energy efficiency, water saving measures, alternative energy sources, fuel spillage, heavy water run-off control strategies and materials and equipment storage are given specific mention within the environmentally aware section. The safe and considerate working environment relates to temporary facilities, PPE’s, health and safety of site operatives and visitors. The BREEAM method also allocates an issue titled “Construction Site Impacts” within the Management Category defined by another technical checklist which outlines best practice requirements related to the CO_2 production from energy use arising from both site activities and materials transport, air pollution, ground and surface water pollution, use of an environmental materials policy and certified timber and implementation of an Environmental Management System.

The AQUA Process is an environmental assessment method adapted to the Brazilian context derived from the French HQE method by the Alberto Vanzolini Foundation (FCAV). It is defined as a process that requires project management to obtain “environmental quality” of a new enterprise or one undergoing renovation (FCAV, 2012). The AQUA process establishes best practices on construction sites within two of its categories: “Integrated choice of products, systems and construction processes” and “Low environmental impact construction sites.” The former relates to materials and product selection based on similar criteria as mentioned in the other assessment methods and the latter is divided into two further subcategories, one of which refers to construction waste management and its reuse and processing within the construction enterprise and the second subcategory requires plans for reducing noise and visual nuisances, nuisances arising from site traffic, particle emissions, dust, mud and concrete Spillage, control measures for air, soil and water pollution and minimisation of resource consumption such as energy and water on construction sites for which many best practices are suggested (FCAV, 2012).

The Selo Casa Azul CAIXA was developed by the Brazilian government owned bank, the CAIXA Econômica Federal and is a social-environmental classification instrument used for residential building projects. It aims to recognise enterprises that adopt efficient solutions applied to the construction, use, occupation and maintenance of buildings by encouraging the rational use of natural resources and improvements in living quality and the building’s surroundings (John et al. 2010). The seal is applicable to all residential enterprise projects that are submitted to the CAIXA bank for financing. The Selo Casa Azul considers the construction phase of an enterprise within the following areas: recuperation of degraded areas, conservation of material resources, reuse of temporary formwork and shoring and implementation of social practices such as educational programs (John et al. 2010).

To identify and compare the contribution of each environmental assessment method towards sustainability on construction sites, the methods were analysed and four generic themes were identified: Resource Consumption; Emissions and Solid Waste; Interface with the External Environment and Intrinsic Quality of the Construction Site. Different environmental aspects which could be allocated within each theme were further identified thus enablinga comparison between environmental assessments (EA) method, as presented in Table 1.

Table 1: Contributions towards sustainable construction sites by EA methods

Generic Themes	Environmental Aspects	Environmental Assessment Method			
		AQUA Process	BREEAM	LEED	SELO CAIXA AZUL
Resource Consumption	Material Resources	X	X	X	X
	Energy Efficiency	X	X		
	Water Management	X	X	X	x
Emissions and Solid Waste	Waste	X	X	X	X
	Air Pollution	X	X	X	
	Water and Soil Pollution	X	X	X	X
Interface with External Environment	Urban / Environment Quality	X	X	X	
	Noise Pollution	X	X		
	Visual Pollution	X	X		
Intrinsic Quality of the Construction Site	Health and Safety		X	X	
	Temporary Installations	X			X
	Innovation		X		X

Here it can be seen that all assessment methods provide best practice guidelines for material resources, waste generation and water and soil pollution. Water management, Air pollution and the urban / environment quality are considered by all but the Selo Caixa Azul. These best practices guidelines provide a means of reducing or completely mitigating the consequential impacts. Those related to resource consumption can be reduced through rational resource use, adopting practices that reduce material losses and selecting materials, products and construction systems with low environmental impacts and low embodied energy considering its whole life cycle process, (Berge 2009). The generation of waste products and other emissions during the different site production activities can be reduced through adequate planning and management. Furthermore, construction waste can potentially be valorised as a raw material or energy source (John 2000). Best practices and technologies aimed at controlling particle emissions during the different site activities can be adopted to minimise risks from air pollution and upon the occupational health of site workers and neighbourhood (Resende, 2007, Kukadia 2003, Usepa 2006). Wastewater produced during site activities can also cause groundwater and natural watercourse pollution, and therefore require plans for water waste management involving infiltration and surface run-off control as to minimise pollution and reduce the risks of contamination (NETREGS 2012). Wastewater and effluents can also cause a loss of the fertile top soil due to erosion which consequently reduces the soil's capacity to sustain local fauna and flora as well as compromising water drainage which can lead to flooding therefore requiring best practices to minimize such risks (Cardoso et al. 2006, Araújo 2008, Pulaski 2004). It is also important to control the impacts caused on the health, safety and welfare of the local neighbourhood as well as the physical, biotic and anthropic environments. By adopting practices that improve safety and minimise the degradation of the environment including any discomforts and annoyances resulting from site traffic, visual and noise pollution which are directly or indirectly caused by the production activities (Cardoso et al. 2006; Gehlen, 2008). The impacts caused on the health, safety and welfare of site workers must also be considered by installing appropriate collective and individual protections during the different activities (Pulaski, 2004). Improvements on the Intrinsic Quality of the Construction Site such as the comfort and environmental performance of temporary facilities may also be required (Araújo, 2008). Innovative technologies can provide significant improvements on the performance of site equipment and facilities, thus providing sustainable solutions for construction sites.

3.Methods

This work consisted of a literature review, as presented in the previous section followed by the formulation and application of an on-line survey. The survey was composed of two sections: the first aims to identify the respondent company in terms of staff numbers, company age, niche markets within the construction industry and whether it is certified under the ISO 9001 management system or the Brazilian Program of Quality and Productivity (SIAC PBQP-H), ISO 14001 environmental management system, ISO OSHAS 180001 health and safety management system and/or has a building enterprise certified for sustainability. The second section is composed of a series of questions divided into the four aforementioned themes (Consumption, Emissions and Waste, Interface with the External Environment and Intrinsic Quality of the Construction Site). Each theme has an introductory paragraph contextualising the problem to help situate the survey applicant. A question was formulated for each possible priority research need derived from the previously identified best practice guidelines. The respondent was required to attribute a level of importance for the development of research in technological solutions and best practices for each question. Respondents were given five multiple choice answers: 1) Unimportant; 2) Little Importance; 3) No defined opinion; 4) Important and 5) Very Important. For each question a sub-question aimed at identifying whether the company adopts solutions for the research area under question within the routine operations of 50% or more of their construction sites.

Data was collected via online survey applied to 151 building companies and developers in four cities and surrounding regions of Brazil. The stratified sample is as follows: 61 construction companies in Salvador-BA, 27 in São Paulo-SP, 33 in São Carlos-SP and 30 in Porto Alegre-RS. Company profiles per city were characterised and then a comparison made between the level of importance and percentage of practices adopted by respondent companies per city per theme. The Intrinsic Quality of the Construction Site theme was further divided into 3 subareas; 1) Health and Safety (IQ-H&S), 2) Temporary Installations (IQ - TI) and 3) New Technologies (IQ - NT). Results are then expressed per theme, showing important and very important frequencies for each research area and the percentage of companies adopting solutions in over 50% of their construction sites. Research areas were considered most important when the sum of "important" and "very important" frequencies was above 50% and unimportant when less than 50%.

4. Results

Company profiles were characterised per city and its surrounding region as follows. **Stratum 1** – Salvador - State of Bahia: The questionnaire was applied to 61 companies, 22 of which responded, (36% return rate). 55% of responding companies have been on the market for over 21 years and 50% have over 100 employees. The majority work within the real estate market (91%) and 45% work with low income housing (HIS). Results show that 91% of companies are certified with ISO 9001 or the SIAC PBQP-H and 23% have an environmentally certified building. **Stratum 2** - São Paulo - State of São Paulo: The questionnaire was applied to 27 companies, 19 of which responded (70% return rate). Results show that 53% of responding companies have been on the market for over 21 years and 79% have over 100 employees. The majority (74%) work within the real estate market and only 11% work with HIS. 63% of companies are certified with ISO 9001 or the SIAC PBQP-H. 68% have a building certified with an environmental assessment method. **Stratum 3** - São Carlos - State of São Paulo: The questionnaire was applied to 33 companies, 12 of which responded (36% return rate). Results show that 50% of responding companies have been on the market for over 21 years and 25% have over 100 employees. The majority (75%) work within the real estate market and 25% work with HIS. 83% of companies are certified with the ISO 9001 or the SIAC PBQP-H. Only 8% have an environmentally certified building. **Stratum 4** - Porto Alegre - State of Rio Grande do Sul: The questionnaire was applied to 30 companies in the city of Porto Alegre, 44% of which responded (43% return rate). 46% of responding companies have been on the market for over 21 years and 31% have more than 100 employees. All companies work within the real estate market and 11% work with low income housing. Only 46% of companies are certified with the ISO 9001 or SIAC PBQP-H and 15% have a building enterprise certified for sustainability.

Figure 1 shows the level of importance frequencies per city for each theme. Comparing the level of importance shows that research in the “IQ –H&S” theme were considered as most important by all cities, and that the “IQ-NT” theme was considered as least important. All results are consistent within the different regions except for the city of São Carlos which considered research in the “Interfaces” theme most important. Themes with lower important and very important frequencies presented higher number of “no defined opinion” answers, which should be taken in consideration.

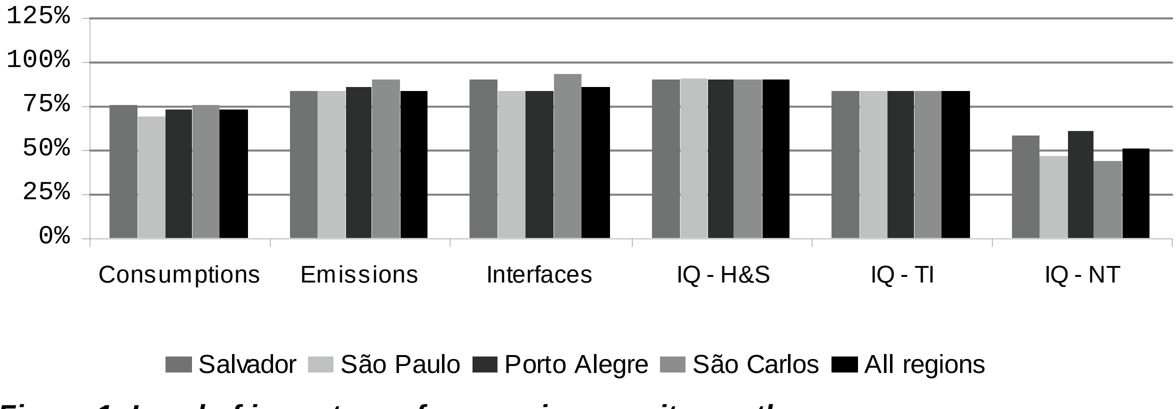

Figure 1: Level of importance frequencies per city per theme.

Figure 2 presents the percentage of practices adopted by construction firms per city and generally per theme where large differences can be observed. The “IQ-H&S” theme presented the highest number of practices implemented by construction firms in all cities, which was also considered as most important, most likely due to the stricter legislations (NBR 18) in place with regards Health and Safety on construction sites. The “IQ-NT” theme also presented the lowest number of practices implemented by companies in all cities. It is important to note that results found for the different themes are consistent among all cities.

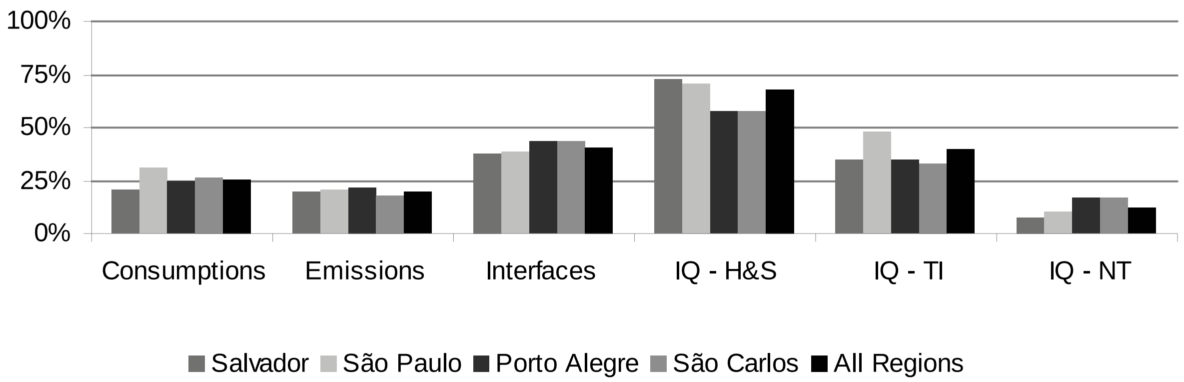

Figure 2: Percentage of practices adopted by construction firms per city per theme.

The following discussion refers to companies from all regions. For the “Consumptions” theme (table 1), research in “reducing material losses during the carrying out of services, deliveries, internal transport, storage and handling of materials in construction sites” was considered as most important (100% of companies), for which 58% of companies adopt practices. Interestingly “Greywater use” and “Use of alternative energy sources, including renewable energy” were considered as unimportant where 0 and 2% of the respondent companies adopt practices respectively despite the former being simple to install, perhaps considered unimportant due to the lack of knowledge on the water economised and how to implement such systems.

Table 1: Important and very important frequencies (I&VI%) and percentage of practices adopted (PA%) – Consumptions theme – All regions

Priority Research Needs - Consumptions	I&VI (%)	PA (%)
• Reduce materials losses during the carrying out of services, deliveries, internal transport, storage, and handling of materials on construction sites.	100	58
• Development of materials, products and construction systems selection criterion from responsible sources that include life cycle analysis information (origin, processing, use e maintenance, durability e disposal) and material properties like technical performance.	95	52
• Improvements of temporary installations with the aim of reducing potable water and electric energy consumption, as also in equipment, lighting and air conditioning systems on construction sites	86	29
• Reduction of Electric Energy Consumption during the Production Activities on Construction Sites	85	18
• Development of a supplier analysis system formalizing aspects related to federal revenues, use of environmental operating licenses, social responsibility, correct use of codes and standards, etc.	85	39
• Rainwater use on Construction Sites	59	5
• Use of alternative energy sources including renewable energy	48	0
• Greywater use on Construction Sites	44	2

For the “Emissions and Waste” theme, all research areas were considered important (Table 2). “Development of technologies and economically viable applications of construction waste materials still without recycling or recuperation solutions (Class C)” was considered most important (98%) although only 16% of companies adopt solutions. This, however depends on research, government incentives and agreements between industrial sectors amoung others. All research areas were considered as important within the “Interfaces” theme (Table 3). Research on “Erosive processes and risks of subsidence” was considered most important and 53% of companies adopt solutions. For all areas at least 27% of companies adopt solutions, thus emphasising the need to identify what is being done by construction firms, where improvements are required and how companies can be trained to adopt more practices.

Table 2: Important and very important frequencies (I&VI %) and percentage of practices adopted (PA%) – Emissions and Waste theme - All regions

Priority Research Needs - Emissions and Solid Waste	I&VI (%)	PA (%)
• Control of generation, quantification, separation, storage and disposal of construction waste on construction sites including Take-back scheme (return of waste products to manufacturers)	97	39
• Development of decontamination technologies and disposal solutions for dangerous construction waste products such as paints, solvents, oils or other contaminated waste products arising from demolition, renovations, radiological clinical repairs, industrial installations among others (Class D)	94	9
• Exploitation and Use of Construction Waste on Construction Sites	91	23
• Development of technologies and economically viable applications of construction waste materials that still have no recycling or recuperation solutions (Class C)	89	17
• Vegetation Preservation methods in construction site areas	85	33
• Sewage catchment and treatment systems and minimization of risks resulting from drainage on construction sites	85	21
• Identification of risks of particle emissions arising from production activities on construction sites and towards the neighborhood	85	21
• Control of groundwater levels, contamination and minimization of risks resulting from its management	85	21
• Characterization, monitoring e control of particle material emissions	74	12

All research areas in the “IQ- H&S” theme were considered as important and over 68% of companies adopt practices. Research on developing and improving “collective protection against falling from heights” “protections against people handling equipment” and “protections against electric shocks” were considered most important for which over 76% of companies implement practices. Although solutions exist, these must be improved. For the “IQ-TI” theme, “Improvements on the work safety conditions” and “health and hygiene conditions inside the temporary facilities” were considered most important (97%).

Table 3: Important and very important frequencies (I&VI %) and percentage of practices adopted (PA%) - Interface with External Environment theme - All regions

Priority Research Needs - Interface with External Environment	I&VI (%)	PA (%)
• Erosive processes and risks of collapse/subsidence	98	53
• Characterization of sound emitting activities and plans to mitigating noise nuisance	92	27
• Management of site access, pedestrian flow, equipment, loading and loading on construction sites	92	55
• Site interferences with local traffic, street conservation and pavements to guarantee accessibility	91	47
• Identification of risks of particle emissions derived from production activities on the neighborhood.	88	30
• Demolition processes and contingency plans	80	29

For the “IQ - NT” the “development of industrialised steel modular temporary facilities (containers)” was considered important by 86% of companies, used by 33% of respondent companies. All regions considered research on “Development of industrialised modular temporary installations in precast concrete, cement slabs or plasterboards for vertical wall systems” as unimportant. No companies use cement slabs, 3% use modular precast concrete and 2% use plasterboard for the vertical wall systems of temporary facilities.

Table 4: Important and very important frequencies (I&VI %) and percentage of practices adopted (PA %) - Intrinsic Quality of the Construction Site theme

Priority Research Needs - Intrinsic Quality of the Construction Site (IQ)	I&VI (%)	PA (%)
Health and Safety – IQ – H&S		
• Collective Protection Equipment against falling from heights on Construction Sites	98	77
• Protections against people handling equipment	98	76
• Protections against electric shocks	98	76
• Safeguards for material handling equipment	97	71
• Machine and equipment protection	97	68
• Protection of excavations	95	70
• National certification system for Industrialized Collective Protection Equipment, similar to existing certification system for Personal Protective Equipment (PPE) on construction sites	79	41
Temporary Installations on Construction Sites – IQ - TI		
• Improvements of work safety conditions inside the temporary installations	97	55
• Improvements of the health and hygiene conditions inside the temporary installations	97	62
• Reuse of temporary installation components and construction systems	92	42
• Improvements in the lighting, ventilation and air quality conditions of temporary installations	89	41
• External visual communication and signaling	86	67
• Improvements in structural safety of the temporary installations	89	41
• Improvements on the connectivity of the temporary installations with water supply networks, sewage treatment, energy and communication lines,	85	35
• Improvements in the operation, use and maintenance of temporary installations	85	29
• Improvements in fire safety of temporary installations	82	41
• Improvements of the water tightness of the temporary installations	82	32
• Furniture and other internal fixed equipment for temporary installations	77	35
• Improvements in the architectural flexibility (lay-out) of the temporary installations	74	32
• Improvements on thermal and acoustic comfort of the temporary installations	73	27
New Technologies – IQ - NT		
• Development of industrialized steel modular temporary installations solutions (containers)	86	33
• Development of industrialized modular temporary installations solutions using wood and its derivatives (eg. OSB)	73	23
• Development of industrialized modular temporary installations using cement slabs in the vertical wall systems	39	0
• Development of industrialized modular temporary installations solutions in precast concrete	35	3
• Development of industrialized modular temporary installations using plasterboard in the vertical wall systems	35	2

5. Conclusion

Priority research areas, number of practices adopted by companies per theme and the percentage of companies adopting solutions for each research area were identified. Research related to “Health and Safety” was considered most important by all regions which also presented the highest number of construction firms adopting solutions, perhaps due to the stricter Health and Safety legislations in place (NBR 18). Results show that many companies implement solutions for the different research areas. It is therefore necessary to identify what is being done by companies and identify why companies are not adopting practices (lack of knowledge, high cost, lack of available technologies among others). Often, sustainable practices can be implemented without high investments but with planning and obligation. Also, some research areas were considered as unimportant and not practiced such as “greywater use.” Here, solutions are simple but require planning and prioritising within a company’s internal policy. Therefore new government policies should be formed with stricter legislations incentivising the implementation of sustainable practices and technologies on construction sites together with training programs so more construction firms can adopt practices. Interviews are being made with construction managers to validate survey findings, identify solutions adopted and the main difficulties and obstacles in implementing practices. From this, it is possible to identify existing solutions, where improvements are required and where New Technologies should be developed. Some research areas were identified as important, but were given less emphasis within the environmental assessment methods, thus offering opportunities for improvement. The technological solutions and best practice needs identified can help governments, research academies, entity classes and private industries in prioritising funding and resources for further research. Finally, results are expected to produce guideline proposals for New Science, Technology and Social policies aimed at environmental sustainability and improvements in working conditions on construction sites with special emphasis on low income housing projects.

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